ENGINEERING NEWS
AND
AMERICAN RAILWAY JOURNAL.

VOL. XLIII. No. 23.

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THE POLLUTION OF THE LOWER PASSAIC RIVER must be stopped by June 1, 1904, according to a resolution adopted by the New Jersey State Sewerage Commission on June 4. The communities that must stop discharging crude sewage into the river before that date are: Paterson, Passaic, Rutherford, Newark, Orange, East Orange, Montclair, Bloomfield, Glen Ridge, Kearny, Harrison and East Newark. In addition, notices to stop polluting the river will be served on the factories now discharging wastes directly into the stream. It is expected that some or all of the municipalities affected by this action will organize sewerage districts, or one inclusive district, for the construction of joint disposal works, but this is left entirely to the several communities. In case two or more communities wish to act jointly the law establishing the State Sewerage Commission provides for organization under the direction of the commission and the carrying out of disposal works by the district or districts. In any case, all plans for sewage disposal must be submitted to the State Sewerage Commission for approval; and this is true for all new sewage disposal work in the state. The members of this commission are as follows: Wm. Hunt, chairman, and David Wallace, M.D., Newark; Chas. Fuller, Bayonne; John Hinchliffe, Paterson; and Chas. F. Harrington, Lyndhurst. Mr. Hunt is now in Europe investigating sewage purification. Mr. Boyd McLean is secretary. The officers of the comission are in the Fuller Building, Jersey City, and it holds meetings at 2.30 p.m., each Monday.

STREAM POLLUTION BY A COAL COMPANY has resulted in the award of $32,708 of damages to Mr. Joseph Stevenson, a miller on Nescopeck Creek, according to a press dispatch. It is stated that Mr. Stevenson sued the Ebervale Coal Co. for $100,000 damages, on account of rendering the water of the creek useless to him for mill and farm purposes by the discharge of culm and sulphur water into the creek.

SEWAGE IRRIGATION WORKS AT GUADALAJARA, Mex., are now under construction, as are also the collecting sewerage system and works for an additional water supply. The estimated water consumption is about 25 gallons per capita, and the population is about 100,000. There will be about 80 miles of sewers, on the separate plan. The sewage farm comprises some 500 acres, only 100 acres of which will be irrigated at present. The land is owned by the State of Jalisco and the income from the farm is to be devoted to charity. The farm is about one-half mile below the city. Distribution of sewage will be by the ridge and furrow system, from about 6,075 ft. of semicircular, brick-lined conduit, 3¼ ft. in diameter. The dry season extends from about Oct. 1 to June 15. During this period there is practically no rainfall, which, with the high evaporation, will permit a heavier rate of sewage application, it is believed, than would be possible in the United States. During the rainy season it is proposed to discharge the sewage into the river below the city, which, it is said, will not cause a nuisance. It will be a year before the works are in use. Mr. C. H. M. Blake, an engineer and contractor residing at Guadalajara, is engineer for the work and has kindly given us this information.

SLOW SAND FILTRATION FOR THE WATER SUPPLY of Pittsburg, Pa., is finally assured. As many of our readers will remember, this system was recommended in the Report of the Pittsburg Filtration Commission, issued over a year ago, after exhaustive studies made under the direction of Mr. Allen Hazen, M. Am. Soc. C. E., as Chief Engineer. Some months ago the sum of $2,500,000 was voted at the polls for water purification, and a few days ago both branches of the city council voted to carry out the recommendations of the commission and instructed Mr. E. M. Bigelow, M. Am. Soc. C. E., Director of Public Works, to prepare plans for slow sand filtration. Some of the mechanical filter interests made a vigorous attempt to secure further consideration for their system, although the report of the commission was unanimously in favor of slow sand filtration. Notwithsanding these efforts the council declared almost unanimously in favor of slow sand filtration. The capacity of the proposed plant will be presumably 50,000,000 gallons a day. An engineer for the work, we understand, is yet to be chosen.

PUBLICITY OF ACCOUNTS OF ELECTRIC LIGHT companies was strongly advocated before the recent meeting of the National Electric Light Association as a means of stemming the tide towards municipal ownership. The leading advocate of such publicity seems to have been Mr. J. B. Cahoon, of Syracuse, N. Y., the new president of the association. Mr. Samuel Insull, of Chicago, ably seconded Mr. Cahoon's remarks on this subject.

A HOT WATER HEATING SYSTEM FOR DELAware, O., it is reported, will be established soon by Mr. Ed. Gwynn, to be run in connection with the electric light plant.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred on the Cincinnati, Hamilton & Dayton R. R., near Hamilton, Ohio, on June 3. A freight train running at about 25 miles an hour left the track at a switch, wrecking the engine and eleven cars and killing five men.

THE AMERICAN LINER "NEW YORK" lost one of her twin screws on May 22 when about 1,000 miles from the Irish coast on her way to New York. The outer end of the shaft, 16 ft. in length, snapped off 12 ins. outside the stuffing box, through which it enters the hull to reach the shaft tunnel. The sleeve in which the outboard shaft revolves, and the steel shell covering this sleeve, broke off with the shaft and the fragments sank, taking the propeller along with them. The port engine at once attained great speed but was immediately shut off by the automatic governors, so that it stopped in about 12 seconds. The rest of the trip was made at a rate of about 15 knots per hour with the remaining screw. The "New York" will return to Southampton for repairs, as there are not suitable facilities in New York harbor. An examination of the hull indicates that the accident was probably due to striking some floating object.

THE SOUDAN RAILWAY, says a report to the French Senate on the budget of 1900, was being operated for 136 miles on Jan. 1, 1900. In the present year 19 miles are to be built, including a bridge over the Bakoy River, at Toukoto. The progress estimated is 80 miles per year, so that at the end of 1904 the line will reach Koulikoro, a point on the Niger, 355 miles from Kayes. The cost of the line is estimated at $23,000 per mile.

THE UGANDA RAILWAY OF AFRICA, according to a Parliament paper just issued, is open for 362 miles, out of the estimated total of 583 miles; and materials are on hand for 155 miles more. The gross receipts from government and general traffic—not including construction traffic—is about $20 per mile per week, which is double the estimate in the 1893 report.

THE RAILWAY MILEAGE OF EUROPE has increased from 83,680 miles in 1875 to 167,439 miles in 1899, according to an article in a recent issue of "L'Economiste Europeen," of Paris. The increase in mileage by countries is given as follows:

Countries.	Mileage 1875.	Mileage 1899.	Increase.
France	12,898	25,897	12,998
Germany	16,109	30,776	14,666
England	16,449	21,528	5,089
Austria-Hungary	10,083	21,805	11,721
Belgium	2,131	3,781	306
Bulgaria	2,131	616	981
Denmark	635	1,617	981
Spain	3,484	8,102	4,618
Greece	7	591	583
Italy	4,578	9,759	5,181
Luxemburg	169	270	100
Netherlands	984	1,694	709
Portugal	641	1,466	825
Roumania	766	1,894	1,126
Russia	9,665	24,808	15,142
Finland	465	1,605	1,139
Servia	465	353	353
Sweden	2,235	6,359	4,123
Norway	311	1,230	918
Switzerland	1,017	2,302	1,285
Turkey	953	978	24
Isles Malta, Jersey and Man	...	68	68
Total	83,680	167,439	83,605

THE CABLE-RAILWAY OF MONTECATINI, Italy, recently built, has a length of 3,936 ft. and grades of from 12 to 38.5%. The motive force is provided by a vertical compound steam-engine of 50 HP., making 150 revolutions per minute; the steel cable has a section of 300 sq. mm., and weighs 2.6 kilograms per running meter. The factor of safety is placed at 12.

THE UTILIZATION OF BLAST FURNACE SLAG for making Portland cement according to the methods of recent German and Belgian works is described in a paper read before the Iron and Steel Institute of Great Britain. The slag is first granulated by running it while hot into water and then after being dried is mixed about half and half with crushed limestone. To this mixture is added about 3.5% of powdered slacked lime. This final mixture is ground in tube mills until the residue on a sieve of 5,000 meshes per square inch is only 2½%, and the residue on a sieve of 30,000 meshes is only 12½%. The powder from the tube mills is mixed with about 8% of water and made into bricks by machinery. These bricks are dried by being stacked in the open and are then burned in special kilns. As described in the paper, each furnace consists, in its essential part, of a series of rings, each 1 to 1¼ ins. in thickness, 8½ ft. inner diameter, and 18 ins. in height. These rings are provided outside with ribs, and placed in such a way, one above the other, that the vertical ribs cover one another, thus forming little vertical channels, all round, in which the air circulates from below the top, like a chimney, thus continually cooling the cast-iron rings from outside, and preventing them from getting overheated. The materials to be burnt are in direct contact with the cast-iron rings, no lining of any kind being provided for. There are 18 such rings, put one above the other, the upper rings—where the greatest heat occurs—being hooped at the joints. The top of each furnace is provided with a cone and a chimney made of sheet iron, 3 ft. in diameter and 30 ft. in height. The cone has four charging-doors, which can be closed by sheet-iron covers as soon as the charging is done. At a depth of 12 ft. from the top the inner diameter of the furnace is lessened to nearly half its inner horizontal section, and on this place provided with a double row of tuyeres to admit compressed air, this arrangement having for its object to burn any carbonic oxide or carburetted hydrogen gas arising from below as completely as possible, as well as to concentrate the heat exactly where it is required, viz., on the place where the formation of the clinker is to take place. Each furnace has a capacity of about 25 tons of clinker each 24 hours. The clinker is ground in ball mills and finished in tube mills.

U. S. EXPORTS to Cuba, Porto Rico and the Hawaiian, Philippine and Samoan islands will reach $45,000,000 in the fiscal year ending this month, says the U. S. Bureau of Statistics. The totals for these islands are: Cuba, $25,000,000; Porto Rico, $2,000,000; Hawaii, $15,000,000; the Philippines, $2,500,000, and for Samoa, $125,000. These figures average twice as much as in any previous year, except in 1892-3 and 4, when reciprocity largely increased our exports to Cuba and Porto Rico. But even in the great export year of 1893, the Cuban business was $24,157,000; that of Porto Rico averaged $2,750,000 in the three years named, and the Hawaiian export for 1899-1900 is five times what it was in 1893 and four times that of 1896. The total imports from Cuba will show a total of about $31,000,000 for this year against $15,000,000 in 1898 and $18,500,000 in 1897; but in the reciprocity years the average imports were over $75,000,000 per annum. The imports from Porto Rico will be $1,350,000, or less than the total for any year since 1880; though this is largely due to the destruction of crops by last year's tornado. The Hawaiian imports will aggregate $21,000,000, or double the yearly average prior to 1896 and 20% higher than any preceding year.

THE COTTON EXPORT OF THE UNITED STATES, in April, 1899, says the U. S. Bureau of Statistics, amounted to 264,044,318 lbs., against 134,397,328 lbs. in April of last year; the respective values compared as $24,684,078 to $8,435,097, and the average price per pound was 9.3 cts. this year and 6.3 cts. last year. Owing to this sharp advance in the price of cotton, and consequently in cotton cloth, the export in cotton goods has fallen off this year, from 31,751,887 yds. in April, 1899, to 10,143,183 yds. in April, 1900; though the value of the export in 1900 was $1,614,812 as compared with $1,911,511 in 1899.

BIDS FOR NAVY SHELLS were opened by the Naval Ordnance Bureau, on June 1, in response to re-letting of this contract. At the opening of bids some weeks ago the proposals of four companies were found to be identical at $310 each for 600 12-in. armour-piercing shells, and $195 each for 600 12-in. common shells; as a result of this evident collusion all bids were rejected. On June 1, the bids were as follows: For 600 12-in. armor-piercing shells, the Midvale Co. bid $255 each; B. Attva & Co., $150 each; Carpenter Steel Co., $144.75 each, and the Firth-Sterling Co., $164 each. For the 600 12-in. common shells, the same companies bid respectively, $85, $110, $132 and $164 each.

THE SURVEY OF THE MOUTHS OF THE YUKON RIVER, ALASKA.

By G. R. Putnam, Assoc. M. Am. Soc. C. E., and R. L. Faris.*

The sudden development of the Klondike gold fields in 1897 created an unexpected demand for transportation facilities. The only all-water route was by way of the Yukon River, and attention was at once directed to this stream. A special apropriation was made by Congress for its survey, the intention being more particularly for a thorough examination of its mouths. Although there had been rumors of a deep entrance to the Yukon, yet the delta of this great river had always been shrouded in mystery. In former years the little commerce with the interior of Alaska had been carried by one or two small river steamers, which received their cargoes at St. Michael, 52 miles† northeast of the nearest mouth of the Yukon, and made the run down the coast and entered the Apoon Pass, a narrow outlet with less than 2 ft. of water on its bar at low tide. It was obvious that it would be a great benefit to commerce to find an entrance for deep draft vessels, as well as a more southerly one, having a longer open season than St. Michael harbor, which is only free from ice for about four months each summer. The required surveys of the delta and mouths of the Yukon and the adjacent coast were carried out by the Coast and Geodetic Survey during the past two years. The results were negative as regards a deep water entrance, but they developed remarkable errors in the geography of the region. The usual conditions encountered in carrying out such work in so high a latitude as well as the geographical interest of the outlet of a great river, warrant some account of these operations.

Off the Yukon Delta Coast, 1¼ Miles from Shore.

Pipe Signal on the Yukon Bar.

As a considerable part of the surveys were hydrographic, and as practically all transportation in this region is by water, the vital part of the outfit was the boat equipment, and the greatest care was bestowed upon this.‡ The "Yukon," a small steamer (length 75 ft., beam 16 ft., draft tight, 4 ft.) specially designed for shoal water navigation and yet with fair seagoing qualities, was built at Morris Heights, N. Y., and then knocked down, each piece being numbered, and shipped by rail to Seattle and thence by steamer to St. Michael, a total distance of near 6,000 miles. At St. Michael the "Yukon" was again set up, completed and launched in six weeks, in time to be used the same season in the hydrography of the river mouths. This steamer is of especially light and strong construction, composite, with steel frames and wood planking, machinery and boiler light and compact, and with a large drafting room and other conveniences for surveying work. The "Yukon" has a coal capacity of about 20 tons, sufficient for two or three weeks of ordinary duty. Besides this steamer there were constructed at the same place two launches, 32 ft. long, 8 ft. beam, 2½ ft. draft, designed likewise for shoal water work, and having machinery and boiler so compact that there was room for several persons to live comfortably aboard of each, and coal capacity for 5 days.

Another small steamer, the "Taku," of nearly the same dimensions as the "Yukon," but of much heavier construction, was built at San Francisco and proceeded to St. Michael under her own steam. There was also a good equipment of whale boats, dinghies, canoes, and two open scows, useful in transporting coal, supplies and camp equipment.

On account of the lateness of the ice in moving out of St. Michael Bay, parties cannot count on reaching this headquarters before the last week in June, and it is prudent to leave St. Michael the first week in October, for the same reason. The total available season is therefore but little over three months, and from this must be deducted the considerable time required in handling the equipment, as the steamers must be launched at the beginning of the season and hauled out and roofed over at the end. This extremely brief season, the great extent of region to be examined and the other conditions of work here (such as unusual expense) all necessitated a careful consideration of the planning of the work so that without sacrificing any needful accuracy, the greatest amount of useful information might be obtained in the limited time. The methods mentioned will generally be those finally adopted in the second season's work.

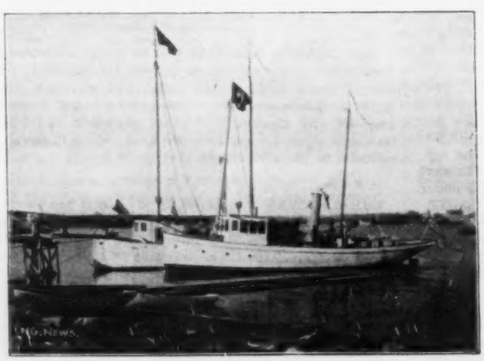
Control.

The astronomical position at St. Michael was taken as the initial point for the surveys. The latitude and longitude had been determined here with care, in 1891, the former by the usual zenith telescope method, and the latter by observing numerous moon culminations and occultations. In the present work additional astronomical observations more or less extended were made at eleven other places, for the purpose of giving temporary starting points for work as well as to furnish a check on the trigonometrical connections. A combination transit and zenith telescope and ten chronometers were carried. The instrument was set up at St. Michael, and then in succession at the various temporary headquarters, and observations for time and latitude obtained as the exigencies of the weather and other work permitted. In connection with the time observations, a mark was set nearly in the [illegible]ian of the transit instrument, where practica[illegible] and by sighting on this before and after ob[illegible]ng the star transits, a fairly accurate azimu[illegible]as obtained with little additional work. [illegible] were introduced into the triangulation thre[illegible]zimuths thus determined and two others obtain[illegible]y theodolite observations on Polaris. In [illegible]section of detached work it proved impracti[illegible]in the course of two weeks to obtain any st[illegible]bserva-tions, so that in this case the position a[illegible]zimuth used depend for the present upon a[illegible]ber of sun observations.

The work is controlled by a system of [illegible]angulation carried from St. Michael, following the coast and adjacent hills to the river, and th[illegible]e along the passes across the delta to the K[illegible]iklowak mouth, and then again along the coast. This triangulation branches off to the Kawana[illegible] mouth and also up the main river to near Andreafski, thus reaching all the important portions of the delta. Such a scheme, following in detail the natural features, was considered much more expedient at present for this region than a larger and more artificial plan, for the reason that the latter would have been much less directly available in the topographic and hydrographic work and also that longer lines would have required much more time because of the little favorable weather. In some of the narrow and crooked passes of the delta the triangulation was involved and difficult, necessitating in one case the use of 109 triangulation stations to cover a distance of 39 linear miles of river.

In the Kwiklowak Pass and main river, however, more favorable conditions were encountered, the river averaging over a mile in width and being comparatively open and straight. Here a distance of 87 miles was triangulated in 28 working days, together with the hydrography and topography, by parties using a steamer, launch and boats. In this part of the work an observer could occupy about six stations a day and locate the intermediate shore line.

Seven and eight-inch theodolites were used and the angles were measured by simply taking a round of directions with telescope direct and then in the opposite direction with telescope reversed, in each case coming back to the starting signal. In a few cases where the ground was unstable the angles were measured by the method of repetitions, having the advantage that the observer is less apt to disturb the instrument by changing his position. At the triangulation stations, also, tangents were taken to islands, bars, bends, etc., and directions (with vertical angles) to hills and mountains, thus materially assisting in filling in the topography. The best instrument for such work in this northern region is a light theodolite with about 7-in. circle capable of being carried attached to its tripod, provided with vertical circle and having lines suited for either stadia work or astronomical observations. Such an instrument should give horizontal angle measures of the needed precision, and at the same time be capable of use for any other work that may arise, a necessary condition for complete mapping along these coasts. In the work up the Kwiklowak Pass and Yukon River the average closing error



U. S. Coast & Geodetic Survey Steamers at St. Michael, Alaska.

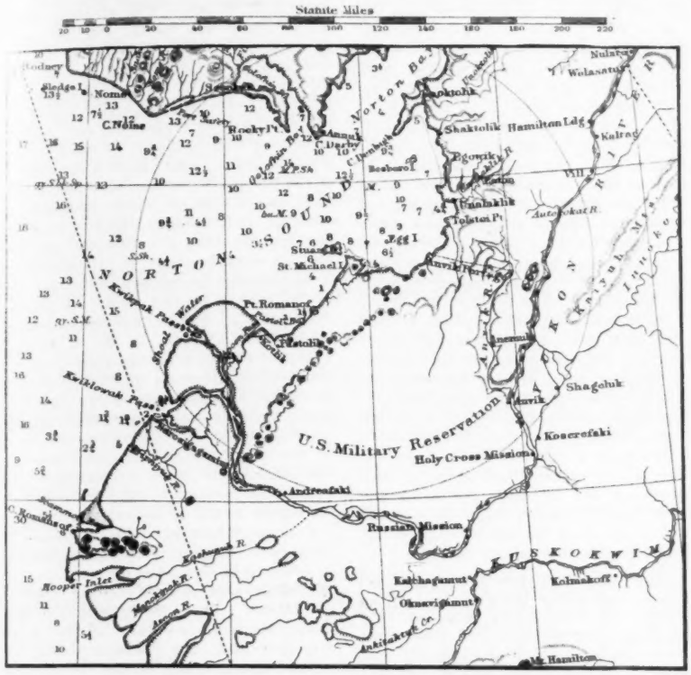
Among the Mosquitoes.

*Assistants, U. S. Coast & Geodetic Survey, Washington, D. C.

†All distances given in statute miles.

‡The equipment for this work was planned by Mr. J. F. Pratt, Assistant, Coast and Geodetic Survey, who also had charge of the first season's surveys.

in 192 tri[illegible] was 10″, and the discrepancies of length[illegible] from one base to another ranged from th[illegible]000th to the 1-3,600th part. Of course, [illegible] that less favorable results were obtained in [illegible] triangulating along the narrower passes. The tri[illegible]tion was carried forward by quadrilaterals [illegible]re practicable, but no great amount of time [illegible] be taken in selecting these or in cutting out lines of sight. It was necessary to utilize all sorts of weather and the stormy days were often spent in signal building when it was sometimes so thick that the stations had to be selected as to their intervisibility by a sort of instinct. A large part of the signals used were built of drift wood varying in diameter and height according to the length of lines; a convenient plan was found to be to drive a large stub well into the ground and in the center of this a wire spike sharp at both ends marked the station; the signal pole having a central hole in its foot was set up over this and braced, and could be quickly lifted off to occupy the station. The stations on the coast and on the hills at the head of the delta and at desirable points along the passes were marked with rocks and bottles; most of the stations in the delta can only be temporary in character on account of the caving banks and the debris of the spring floods. Eight base lines were measured in the delta, one at St. Michael and one at Scammon Bay, all these except the latter being connected in one scheme of triangulation. In the delta the average distance between bases is 21 miles, it being thought much more economical to preserve a sufficient linear accuracy by the measurement of frequent bases than by elaborate angle measurements. In this region the open flats and sand bars afforded excellent opportunity for base measurement. In general these bases are sides in the regular triangles, and average 1.1 miles in length. They were measured with steel tapes lying on the ground stretched under constant tension, the lengths being marked by pins stuck in the sides of stakes. Thermometers were fastened directly to the tapes. As an example of this work, the Great Bend base, 1.5 miles in length, was ranged out and measured twice in one-half day. The two measurements differed by the 1-30,000th part; usually the agreement of measurements was much better than this.



MAP SHOWING OUTLINE OF YUKON DELTA.

Topography.

The topography of the shore and immediate coast and delta regions was developed as an essential part of the surveys. A considerable variety of methods was used. The coast between St. Michael and the river and some other portions were done with the plane table; the front of the delta and Scammon Bay were surveyed by transit and stadia traverse lines; and the river topography through the delta channels was obtained with sextant, theodolite and sketch book. The Coast and Geodetic Survey plane table was employed, a stable instrument with board 24 ins. by 30 ins. Celluloid instead of paper sheets were considerably used for the reason that, being unaffected by moisture, work could be continued uninterruptedly during the light drizzles and mists so frequent on this coast and which would quickly ruin a paper sheet. With the partial protection of an umbrella work could be carried on with the celluloid during any rain that would permit the use of the telescope or sighting upon the rod. The celluloid used was in thin white sheets, 20 × 50 ins., rolling like paper, and having a smooth, hard ground surface, pleasant for drawing, and retaining pencil marks much better than paper.

Sounding on the Bar, Apoon Mouth of the Yukon.

Surveying Launch.

The objection to the material is that it draws up along the edges and that it does not retain ink well, but the latter may be partially overcome by moistening with alcohol before inking. The celluloid contracts with time, but uniformly in all directions. Generally the topography done on celluloid was transferred to projections on paper sheets for final preservation. Special stadia rods were made for this work having very prominent and self-speaking marks, especially conspicuous at the hundred-meter intervals. It is believed that the nearest meter can be estimated as accurately from the ten-meter graduations used on these rods as it is ordinarily read in such work and the omission of the numerous fine points diminishes the liability to large errors and greatly facilitates the reading of the rod. In favorable weather the marks on this rod could be seen at 1,000 meters distance, though not intended to be used at more than 600 meters. Diagrams specially prepared for convenient field use were employed to derive the elevations from the observed vertical angles and distances.

A transverse line was run along the coast of the delta of the Yukon River from the Kwiklowak to the Appon mouth, a distance of 83 miles, and the topography was sketched from the traverse stations, of which there were 271 at an average distance of nearly 500 meters. No white man had ever passed around this shore, and its survey was considered something of a problem on account of the extremely shoal water between the channels and because of the character of the coast, marsh and mud, cut by numerous outlets. The work was successfully accomplished by an observer, accompanied by three men (rodman, boatman and cook). All supplies, including several weeks' provisions, were carried in a Petersborough canoe and a small dinghy. It was necessary to have the canoe constantly follow to ferry across the deeper channels; in places the water was so shoal that at low tide the canoe would be compelled to keep so far out as to be visible from the shore only with a field glass. This arduous piece of work was accomplished between August 5 and Sept. 8 in 21 actual working days. The instrument used was a 7-in. engineer's transit with a special graduated stadia rod (similar to that used on the Mexican Boundary Survey). The limitation of size of party, due to difficulties of transportation, prevented the use of more than one rodman; therefore only forward readings for distance were taken, and the backsights were made on stakes left at each station. As a check the half distance was read. In some cases it was necessary to triangulate across streams. This traverse line is controlled by its joining the delta triangulation at each end and at an intermediate point, the Kawanak mouth. No great precision could be looked for in working in this manner along a marshy shore, but the agreement with the triangulation was sufficient for the purposes intended. At Scammon Bay the topography was obtained by the transit and stadia method, controlled by triangulation and traverse, only the actual shore line being rodded, and the elevations determined by intersections. A useful method was employed here in locating inaccessible features at the water line, such as breakers, sand bars, etc. The elevations and positions of several high points overlooking the bay were determined, and from these the directions and vertical angles of depression to the desired features were observed. Using the elevation as a base the distance can be readily computed or read from a diagram (allowing for curvature and refraction where necessary) and the points at sea level plotted. This principle was used to advantage in making a reconnoissance of a considerable stretch of unknown coast, as well as a portion of the river, of which time did not permit the survey. It is believed that it would be especially valuable when working along an elevated coast in locating off shore rocks and breakers and in making certain the identification of those located by intersections from several points.

The greater part of the shore line of the delta channels was located with the sextant. At all prominent points two or three sextant angles were taken on the triangulation signals, and these

were recorded in a book containing a continuous sketch of the river banks, bars, islands, etc. In the office these positions were plotted with a three-arm protractor in the same manner as boat positions in hydrographic work. To assist in controlling and filling in the topography, tangents to bends, bars and islands were taken with the theodolite when observing at the triangulation stations. The necessary nearness and frequency of these latter also gave a good control to the topography. This method of work was found to be efficient and rapid, and its accuracy simply depends upon the number of positions taken. The following method of work, combining all the operations in an economical manner, was adopted on the larger channels and main river. The steamer proceeded up one bank and the steam launch up the opposite bank, erecting triangulation signals at convenient intervals. Usually the worst weather was utilized for this part of the work; about 16 signals could be built in a day. After going up the river a distance of perhaps 20 miles, two boat parties started down, one following each bank, observing the angles at the triangulation stations and taking sextant angles and sketching for the topography. At the same time the steam launch filled in the hydrography for the same stretch. Towards evening the steamer dropped down the stream and picked up all hands. Sketches of 5 to 10 miles of river were thus covered in one day.

All elevations were located and heights determined from the triangulation stations. The new photo-topographic cameras of the Coast and Geodetic Survey were used also to some extent, rounds of photographs being taken from the triangulation stations, and these aided much in working up the topography, although in general this region is too flat for a profitable application of photographic methods.

As four different topographic methods were used on this work, there was an excellent opportunity to compare their merits. The conclusion is that the plane table is to be preferred wherever practicable as having the great advantage of showing at all times the progress made and of permitting the filling in of the detail in actual view of the country being mapped, but in the work under consideration it would have been inconvenient and less accurate than the transit in running the long traverse along the marshy borders of the delta, and it certainly would have been less economical than the sextant method in the delta channels with banks thickly covered with bushes.

Hydrography.

The hydrography was the main object and most important part of the work, but, as in all surveys, it was so dependent upon the land operations that it naturally follows them in the description. The equipment of steamers, launches, and boats was especially designed, as already mentioned, for work in shoal water. No matter how deep channels might be found, it was appreciated that in seeking them in this region much shoal water would be encountered. On account of the narrowness and crookedness of the channels and sudden changes in depths, both steamers and launches were often aground, but were generally able to work off with but little delay. The steamers were provided with capstans both fore and aft for kedging off when an adverse current or wind would hold them on a shoal. To show the nature of this coast it may be related that in steaming from Scammon Bay to St. Michael running the first line of soundings obtained around the Yukon delta, the steamer "Yukon" grounded off the Kawanak and Kwikpak mouths when 17 miles off the land, according to the old chart (though actually only 9 miles). The little steamer was left by a rapidly falling tide in water so shoal that the men could wade round her, but came off all right with the flood tide. During this voyage of 200 miles, although keeping close in with a steamer drawing less than 5 ft. of water, the shore of the delta coast was never sighted.

The hydrography was developed between St. Michael and the river, at the various river mouths and up the passes as far as the surveys proceeded, and in Scammon Bay. The triangulation signals were found sufficient for the hydrographic purposes in most of this work.

In following out the off-shore bar channels, however, special provision had to be made, for long before the bars were crossed all land-marks and shore signals had disappeared. At first it was attempted to build wooden tripod signals in shoal water, but at high tide the combined effect of wind, waves and buoyancy usually destroyed these. In 1899 an iron-pipe signal was adopted which was simple, economical and efficient. Tripods were set in the water, composed of three 20-ft. lengths of ordinary ¾-in. iron gas-pipe, provided with cross fittings at the top through which they were bound together with telegraph wire. Sticks with flags were put in the upper sockets of the fittings and broad banners of black cloth were fastened around the tripod. These signals were set up either from the bridge of the steamer or from a small boat, the pipe being driven or worked a foot or so into the sand. Most all of them stood successfully, even on the outer edge of the bar. They were lighter, cheaper, and much less bulky than wood for the same purpose, and could be erected in a few minutes. Their positions were determined partly from the shore triangulation stations and partly by a sextant triangulation carried from signal to signal. Such signals were observed with the sextant over four miles off. In some cases single pipes driven in the sand and mud bottom were used, but the diameter was too small to render their permanency certain.

It was often found extremely difficult to follow and sound the narrow and tortuous channels among the bars with a steamer, but it was not considered practicable to use either steam launch or pulling boats in this off-shore work, for the reason that to observe from the water level would have required many more signals than from the elevated bridge of the steamer.

In connection with the hydrography the tides were observed at 27 points (some for short intervals) and currents and sea water densities were measured as opportunity offered. Self-registering tide gages were maintained at St. Michael and at the Kwiklowak mouth of the Yukon. In addition, tides were observed in the vicinity of the sounding work. The steamer anchored on the bar several times and set out temporary tide staffs to determine the relation in time and range between the tides there and at the tidal station.

Summary of Results.

The following is a brief summary of the work during the season of 1899, between July 9, when the parties left St. Michael, and September 15, when they returned there to put the steamers in winter quarters: Astronomical stations, 11; triangulation stations, 412; topography, miles of coast, 270; miles of river shore, 525; miles of sloughs, 280; hydrography, miles of soundings, 2,300; number of soundings, 65,000; magnetic observations at nine stations. The work of 1899 is plotted on 40 topographic and hydrographic sheets mostly on a scale of 1-20,000th. This scale was as small as it was convenient to plot the hydrography. While smaller scales might have been used for the topography, it facilitated the work to have the sheets uniform.

Some of the more interesting geographic results of the work are these: It is 94 miles around the front of the delta from the Kwiklowak to the Apoon Mouth, and to the head of the delta it is 45 miles from the former and 58 miles from the latter by the river channels. The real delta of the Yukon is probably very much longer than this, as the Kashunuk slough is reliably reported to leave the river some distance further up and to empty into Behring Sea 100 miles south of the Kwiklowak, making a total area in the delta of 9,000 square miles. There are 26 outlets of the river more than 200 yards in width at the coast; of these the three most important, the Kwiklowak, the Kawanak, and the Apoon, were sounded out. The latter gets its importance from its position rather than its size, as it discharges less than 1% of the water of the river. It has less than 2 ft. of water on its bar at low tide, but it is the only mouth used or likely to be used, because of its convenience to St. Michael, and the fact that it is the only mouth having land marks in sight in crossing the bar. The Kawanak, discharging about 14% of the river water, has apparently the best channel to sea with a depth of 9 ft. The Kwiklowak, much the largest pass, carrying 75% of the water of the river, divides into five channels at its mouth, the best of which has only 7 ft. to sea. In the main channel the shoalest part of the bar is five miles from the coast and 18 miles from the mouth. Above the mouth this pass has a channel with a minimum depth of 20 ft. as far as surveyed (to miles to near Andreafski). The greatest depth obtained in the river was 84 ft., and the greatest width of open water 2.2 miles. The small depths off the mouths are surprising in view of the magnitude of the river, which ranks among the largest in North America. A cross section of current observations were obtained at a point where the river was well confined, 73 miles from the Kwiklowak mouth. These gave a discharge on Sept. 8 of 436,000 cu. ft. per second, which is slightly more than two-thirds the mean discharge of the Mississippi. It is thought that this is about the average for the year, for although the river was at its low summer stage, it undoubtedly falls lower in winter and the banks showed that it rises about 12 ft. higher at this point in the spring. The tides at the Yukon mouths are small, with a mean range of 4 ft. A tide of about 5 ins. was observed 62 miles up the river from the Kwiklowak mouth. It is an interesting fact that at the Kwiklowak mouth there are two tides a day, while at the Apoon mouth there is but one. The question of possible improvement of the mouths of this river in case commercial development should demand it is interesting because of the conditions existing so near the Arctic Circle. The ice action would be an important factor.

A considerable error in the coast line of the delta was developed by these surveys, moving it seaward in one place as much as 35 miles, and adding an area of 3,000 square miles to this part of Alaska. The long reported delusion of the great width of the bars off the Yukon is thus dispelled and the reason some ships have grounded apparently so far from the coast is accounted for.

THE MICHIGAN ALKALI CO.'S PLANT FOR MANUFACTURING PORTLAND CEMENT FROM CAUSTIC SODA WASTE.

By B. B. Lathbury, Assoc. M. Am. Soc. C. E.*

The interest manifested in the manufacture of Portland cement in this country during the past ten years, and the phenomenal increase in its production, due not only to the enlargement of existing plants, but to a greater extent to the large number of new plants erected, has aroused financial interest in Portland cement manufacture in new and undeveloped localities. As a result of this wakening among men with money to invest there has been a tendency to experiment with materials heretofore never successfully utilized for the production of Portland cement on a commercial scale.

The earlier history of the Portland cement industry in this country centers around that section in Pennsylvania close to Allentown, which is commonly known as the Lehigh Cement District, where the raw material used is argillaceous limestone. The productive zone afterward extended northward through New York State, where marl and clay as raw materials were principally utilized. The next locality developed was in the State of Ohio. The mills erected during the early development in this state manufactured cement from marl and clay. Afterwards came the utilization of limestone and clay, and the gradual expansion of the industry westward by the erection and successful operation of mills using both marl and limestone in the states of Ohio, Indiana, Illinois, Michigan, Wisconsin, Texas, Utah, and even into the far northwest, Dakota. The careful study of conditions, made necessary by the contemplated use of different materials, has necessarily brought about radical changes in the method of manufacture, until at the present time 90% of the Portland cement produced in the United States is manufactured in this country by the rotary kiln process from materials such as the argillaceous limestone, found principally in the Lehigh Dis-

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trict; the marl and clay deposits of New York, Ohio, Michigan and Indiana; and the limestone and clay deposits of New York, Ohio, Illinois, and, on a smaller scale, in a few other western states.

The increased use to which Portland cement has been put, during the past five years, has stimulated the rapid development of the large industry; and while new plants have been erected from time to time, the increased production has barely supplied the almost phenomenal demand. This demand has not only induced capitalists to invest millions of dollars in a thoroughly safe and profitable industrial enterprise, but has influenced scientific experiment with various raw materials to ascertain their suitability for use in the manufacture of Portland cement.

Some years ago experiments were made in France with the waste product from the manufacture of soda with a view of ascertaining whether when mixed with suitable clay, it could be utilized as an ingredient to produce Portland cement. The results, however, did not warrant the erection of a plant in order to produce cement on a commercial scale. Laboratory experiments were also conducted with such waste in England as early as 1870, but they also were unsuccessful, due principally to the deleterious effects of the sulphur compounds existing in the waste. Later the English chemist, Chance, announced his recovery process for the separation of the calcium and ferrous sulphates from the waste, but the method, it appears, was never employed commercially, due, no doubt, to the expense in treating the raw materials.

During the past five years, the waste product from the caustic soda plant at the works of the Michigan Alkali Co., located at Wyandotte, Mich., has been slowly accumulating at the rate of about 110 tons per day. Means were sought to dispose of this material to a number of industries, but without success, and it was decided in 1897 to conduct experiments and make a careful and thorough investigation into the value and adaptability of the material as a lime ingredient, for the manufacture of a high grade of Portland cement. The experiments were undertaken by the firm of Lathbury & Spackman, and of which the writer is a member, to whom also was entrusted later on the design and construction of the entire plant. The investigation extended over a period of one year, and embodied both chemical and physical laboratory experiments.

The raw materials used in the investigation were the residuum or waste from the caustic plant, which is pure white in color, free from grit, and practically a precipitated chalk, containing approximately 40% of water, and the bluish clay obtained from the lowlands bordering the Detroit River on the property of the company, south of Works No. 1. The samples secured at various times during the progress of the experiments, gave fairly uniform chemical results, of which the following are average analyses of both the waste and clay:

Waste.		
Calcium carbonate ($CaCO_3$)	74.85%	= 50.40% CaO.
Calcium hydrate ($Ca(OH)_2$)	11.24%	
Magnesium carbonate ($MgCO_3$)	8.24%	= 4.97% MgO.
Magnesium hydrate ($Mg(OH)_2$)	1.52%	
Silica (SiO_2)	.98%	
Alumina and iron oxide*	1.62%	
Sulphur (S)	.06%	
Alkalies ($K_2O.Na_2O$)	.50%	

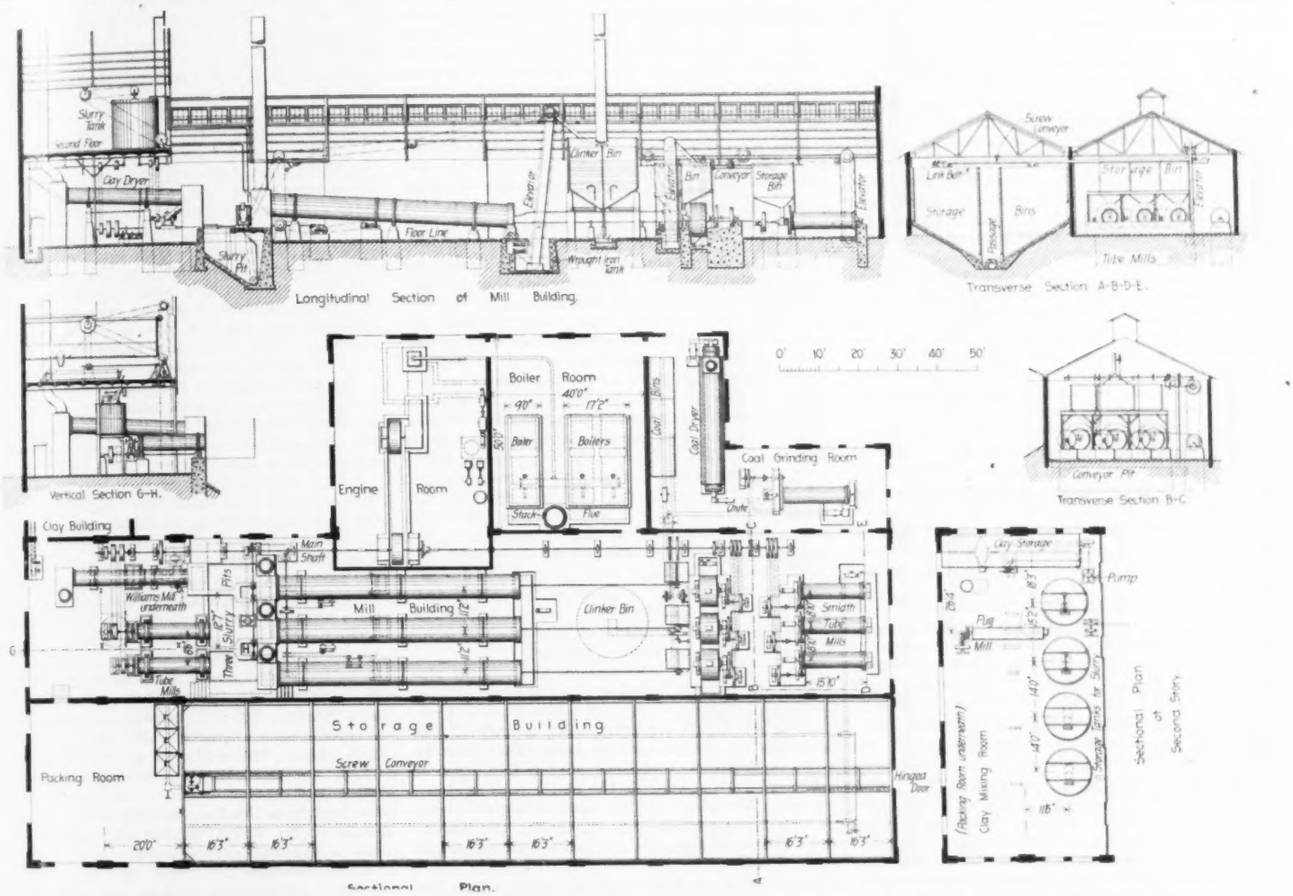
*($Al_2O_3 + Fe_2O_3$).

Clay.	
Silica (SiO_2)	46.81%
Alumina and iron oxide ($Al_2O_3 + Fe_2O_3$)	14.21%
Calcium carbonate ($CaCO_3$)	25.07%
Magnesium carbonate ($MgCO_3$)	7.58%
Sulphuric anhydride (SO_3)	1.18%
Alkalies ($K_2O.Na_2O$)	3.04%
Loss on ignition	15.75%

Unlike the English alkali works employing the Leblanc Process, the Michigan Alkali Co. use the Ammonia Soda Process, giving a residuum practically free from sulphate of lime; therefore the deleterious effects of the sulphur compounds which had proved so disastrous to the English investigations are entirely removed. Considerable doubt, however, was created by the high magnesia content due to the quality of the limestone, which was first burned and afterwards used in the caustic soda plant. Another unfavorable condition presented itself in the considerable percentage of uncombined silica in the clay due to the coarse grit found throughout the deposit.

Burnings were undertaken in a small downdraft vertical kiln from different mixtures of the waste and clay with results not wholly satisfactory. The resulting clinker was largely underburned, due to the insufficient heat in the kiln. Proper correction for this defect being found, a hard-burned, dark green, crystaline clinker was produced from a mixture of 100 parts clay to 260 parts of waste by weight. Briquettes were made from the cement of this burning and tensile tests carried over a period of one year, and the strength, both of neat cement and of three parts sand to one part cement mortar, incresed normally from seven days up to one year, showing the quality to be equal to the very best American or imported cements. The cement was also subjected during the entire year to the most severe tests to detect any injurious effects from the high magnesia content, but under all conditions the specimens maintained their constancy of volume with absolutely no signs of disintegrating or cracking, whether allowed to remain in air or immersed in water at varying temperatures. Notwithstanding the high magnesia, the results clearly demonstrated the entire suitability of the material for the manufacture of the highest grade of Portland cement. A favorable report was therefore rendered, with the suggestion, however, that by using a limestone with a lower percentage of magnesia, results would be obtained which would place the cement on an equal basis with all others manufactured, and thereby avoid possible unfavorable criticism.

Steps were immediately taken therefore to lo-



PLAN AND SECTIONS OF THE MICHIGAN ALKALI'S PLANT FOR MANUFACTURING PORTLAND CEMENT FROM CAUSTIC SODA WASTE.
Lathbury & Spackman, Philadelphia, Pa., Engineers.

timber framework has been almost entirely eliminated in order to avoid the liability of loss arising from fire.

The conveying and conveying machinery throughout the plant is most complete and substantial in character, having been designed with a view of further reducing the idea of avoiding manual labor as far as possible. The movement of all elevators and conveyors is dependent on the operation of the individual machine or group, which they either feed or from which they remove the material. With the exception of the few men required in the mill to look properly to care for the machinery and look after its adjustment, and also the usual number required for packing and handling the finished cement, while it is being loaded on the cars, there will be little use for manual labor, as the plant in operation is as nearly automatic in the process of manufacture as it is possible to make it. The only detached building is one located between the mill and the river, in which are well-equipped chemical and physical laboratories, together with offices for the Superintendent.

A notable feature of the plant is the relatively small area covered by the buildings when compared with the total capacity, which makes it one of the most complete plants in operation. Including the stockhouse, with a capacity of 40,000 barrels of finished cement, all the buildings only cover an area of 25,000 sq. ft., while the capacity of the plant is 450 barrels per day. The machinery is so arranged that while all available space in the buildings is utilized, care has been taken to avoid any crowding, and access can be readily gained to all machinery and apparatus for necessary repairs or adjustment.

The plant, being located on the Detroit River, affords excellent facilities for water shipment by the Great Lakes. There are also railroad switches from the Lake Shore & Michigan Southern and the Michigan Central railways, which run directly into the works. The plant is operated as part of the Michigan Alkali Co.'s works, and the waste product is delivered to the cement plant at a fixed charge per ton, which about represents the cost of excavating and hauling it from the caustic soda building to the cement plant. It is only necessary, therefore, for the clay to be excavated from the adjoining field and hauled to the mill in steel cars, which is effected at a small cost.

The plant has been in operation since September, 1899, and ample time has thus been afforded to carefully observe not only the process and cost of manufacture, but also the quality of the product. As the cost of delivering the raw materials at the mill is low, and the machinery and equipment being favorable for economic manufacture, a Portland cement of the highest grade is produced at a low cost. The problem, therefore, seems to have been solved for the utilization of this residuum or waste product from the caustic soda plant, and whereas it has formerly been a burden and expense to handle it, by such conversion it has now become a valuable by-product, and a source from which the Michigan Alkali Company will enjoy a profitable revenue.

STRENGTH OF CONCRETE WITH DIFFERENT PER CENT. OF VOIDS FILLED.

By Wm. A. Hawley and B. F. Krahl.*

Two very common errors in writing the specifications for concrete are: (1) Screened stone is required when unscreened would be better; and (2) the proportion of mortar is fixed independently of the voids in the stone. Screened stone contains a greater percentage of voids than unscreened, requiring more mortar for the same volume of stone, and is, therefore, more expensive. It appears to be the universal custom to fix the proportion of mortar and broken stone independently of the per cent. of voids, and, therefore, the resulting concrete may be dense and strong, or the reverse, according to the percentage of voids in the stone.

The writers made a series of experiments to determine the strength of concrete having different relations between the voids and the mortar. Alpha American Portland cement, blue limestone, and drift sand were used. The proportions of the mortar were 1 to 3 by volume, loose. The per cent. of voids filled were 125, 100 and 75, respectively. The sand and cement were thoroughly mixed dry, and in such quantities as required for a complete set of cubes or bars at one time. The same size and grade of broken stone was used throughout the tests. Great care was taken to mix the mortar in the same maner each time, to use the same relative amount of water, and to make and tamp the concrete in the same manner.

To determine the crushing strength, 6-in. cubes were used; and to determine the transverse strength, bars 6 × 6 × 18 ins. The cubes and bars were allowed to remain in the laboratory for 48 hours, covered with a damp cloth, when they were removed from the molds, and placed under water to remain the specified time.

The results of the tests for the crushing strength of the cubes are shown in Table I., and of the tests for the transverse strength of the bars in Table II. Table III. shows the relative strength of each grade of concrete, and Table IV. the relative cost of a cubic yard of each.

By an examination of Table III. it is seen that an increase of 25% in the amount of mortar, increases the crushing strength 53%, and the transverse strength 15%, or an average increase in strength of 34%. With a corresponding decrease of 25% in the amount of mortar, there is a decrease of 21% in the crushing strength, and of 38% in the transverse strength, or an average decrease in strength of 30%. From these results it is seen that the strength of concrete varies more rapidly than the per cent. of the voids filled. The maximum strength would probably be obtained when the concrete contains no voids and is a perfectly uniform and solid mass. In Baker's "Treatise on Masonry Construction," it is shown that when an amount of mortar equal to 100% of the voids is used, the voids are not entirely filled, as each stone becomes covered with a thin layer of mortar, thus forcing them apart, and increasing the amount of voids. To fill the voids entirely an amount of mortar equal approximately to 140% of the voids is necessary.

In order to obtain the relative cost of concrete, proportioned as in these experiments, Table IV. was computed. No allowance was made for the cost of labor; but as this would be nearly the same for all, the omission would not affect the relative cost.

According to Table IV., the concrete, which has an amount of mortar equal to 125% of the voids, is the most economical of the concretes investigated; since for an increase in cost of 14%, there is an increase in strength of 34%, while for a decrease in cost of 14%, there is a decrease in strength of 30%.

TABLE I.—Showing Crushing Strength of 6-in. Concrete Cubes.

	Crushing strength. Per cent. of voids filled with mortar. 125. Approx. corresponding to 1—3—6. Total.	125. Lbs. pr sq.in.	100. Approx. corresponding to 1—3—7.5. Total.	100. Lbs. pr sq.in.	75. Approx. corresponding to 1—3—10. Total.	75. Lbs. pr sq.in.
7 days	52,100	1,447	42,480	1,180	31,010	861
	56,730	1,576	45,690	1,269	31,940	887
	62,200	1,728	50,280	1,397	33,390	927
Mean	57,010	1,584	46,483	1,282	32,113	892
30 days.	69,000	1,917	66,000	1,833	61,800	1,717
	65,000	1,806	64,200	1,783	54,200	1,505
	59,800	1,661	50,400	1,400	43,000	1,194
Mean	64,600	1,795	60,200	1,672	53,000	1,472
90 days	97,000	2,694	43,250	1,201	37,900	1,035
	93,000	2,583	38,000	1,055	28,250	785
	88,000	2,444	.....	.....	.....	...
Mean	92,666	2,579	40,625	1,128	33,075	919

TABLE II.—Showing Transverse Strength of 6×6×18-in. Concrete Bars.

	Breaking load. Per cent. of voids filled with mortar. 125. Approx. corresponding to 1—3—6. Total.	125. Unit stress Lbs. pr sq.in.	100. Approx. corresponding to 1—3—7.5. Total.	100. Unit stress Lbs. pr sq.in.	75. Approx. corresponding to 1—3—10. Total.	75. Unit stress Lbs. pr sq.in.
7 days	2,780	347	1,790	224	1,750	219
	2,520	315	1,850	229	1,350	194
Mean	2,650	332	1,810	226	1,650	206
30 days	3,980	498	4,240	530	2,170	271
	3,800	475	3,910	489	1,860	232
Mean	3,890	486	4,075	509	2,015	252
90 days	4,820	602	5,000	625	2,000	250
	5,050	631	4,800	600	2,500	312
Mean	4,935	617	4,900	612	2,250	281

TABLE III.—Showing Relative Compressive and Transverse Strength of Different Grades of Concrete.

	Per cent. of voids filled with mortar. 125. Approx. corresponding to 1—3—6.	100. Approx. corresponding to 1—3—7.5.	75. Approx. corresponding to 1—3—10.
	Crushing Strength.		
7 days	123%	100%	69%
30 "	107%	100%	68%
90 "	228%	100%	81%
Mean	153%	100%	79%
	Transverse Strength.		
7 days	146%	100%	91%
30 "	95%	100%	49%
90 "	100.7%	100%	46%
Mean	115%	100%	62%

TABLE IV.—Showing Relative Costs of Different Grades of Concrete.

Material.	Price.	Per cent. of void filled with mortar. 125 Approx. corresponding to 1—3—6. Amt.	Cost.	100 Approx. corresponding to 1—3—7.5. Amt.	Cost.	75 Approx. corresponding to 1—3—10. Amt.	Cost.
Stone	$1.50 c. yd.	0.94yd.	$1.41	0.97yd.	$1.46	0.99yd.	$1.48
Sand	.75 "	.44 "	.33	.35 "	.26	.26 "	.23
Cement	3.00 barrel	.86bbl	2.58	.69bbl	2.07	.52bbl	1.56
Total cost			$4.31		$3.79		$3.24
Relative cost, %			114		100		86

*Abstract of a graduation thesis, prepared by these two members of Class of 1900, at the University of Illinois, Champaign, Ill.

BOOK REVIEWS.

THE ELECTRIC AUTOMOBILE; ITS CONSTRUCTION, CARE AND OPERATION.—By C. E. Woods, E. E., M. E. Chicago: Herbert S. Stone & Co. Cloth; 5 × 7½ ins.; pp. 176; illustrated. $1.25.

This book has been prepared expressly for the lay reader and the information given is of a general nature. The important parts of an electric vehicle, such as the tires, batteries, motors and steering gear, are discussed at some length, and directions are given in regard to care and management. The book is printed, not very tastefully, on imitation hand-made paper with uncut edges, and the illustrations are half-tone cuts of complete vehicles together with a few details.

THE LOCAL GOVERNMENT ANNUAL AND OFFICIAL DIRECTORY.—Edited by S. Edgecumbe Rogers. London, Eng.: The Local Government Journal. Cloth; 5 × 7 ins.; pp. 348; tables. 2½ shillings in Great Britain; $1 in America.

This volume contains a variety of information relating to English municipalities, being particularly complete for Greater London and its several parts. For cities, towns and boroughs outside of London, less information is given, but the publishers claim that "the names of the chief officials of every public body in England and Wales" are given. These names include town engineers and surveyors, a feature of special value to those wishing to reach this class of officials by correspondence.

RECHERCHE DES EAUX POTABLES ET INDUSTRIELLES.—Par Henri Boursault, Chimiste à la Cie. Chemin de Fer du Nord. Paris: Gauthier-Villars. Paper; 7½ × 4½ ins.; pp. 200; illustrated. 2.50 francs (75 cts.).

The author takes up the preliminary study of a water supply for domestic or industrial purposes. He discusses the character of the rocks and soils in which water is found; and water itself from subterranean and surface sources in all the detail of circulation as modified by the materials traversed. Chapter V. is devoted to the quality of water, from the sky and from surface streams and subterranean sources, and its temperature, limpidity and natural filtration. The author points out the methods to be followed under varying conditions, in studying the geological features, the character of the stream bed and banks, chemical analysis, gaging of flow, etc. He illustrates the situations discussed by simple cross-sections.

THEORY AND PRACTICE OF INTERPOLATION: Including Mechanical Quadrature and Other Important Problems Concerned with the Tabular Values of Functions. With the Requisite Tables. By Herbert L. Rice, M. S., Assistant in the Office of the American Ephemeris, and Professor of Astronomy in the Corcoran Scientific School, Washington, D. C. Published by the Author. Cloth; 8 × 11½ ins.; pp. 234; tables. $3.50.

The preface states that the author has repeatedly felt the need of a work which would give, exclusive of other matter, a simple, practical, yet comprehensive, discussion of all that is useful concerning Differences, Interpolation, Tabular Differentiation and Mechanical Quadrature; a work, moreover, which would include all tables appertaining to the text which are required by a practical computer. To supply the want thus conceived, the author offers the present volume.

The text is written in a lucid style and offers few difficulties to one having a working knowledge of the infinitesimal calculus. Although the demonstrations are often necessarily long, the final results are stated in the most convenient form for use and are illustrated by examples. We believe that the book will be found useful by physicists, astronomers and others having much to do with observed numerical values or computed tables.

cate a quarry containing a more suitable limestone for use in the caustic soda plant. Such a deposit was found near Bellevue, Mich., and afterwards purchased by the company. An average analysis of this limestone contains:

Calcium carbonate ($CaCO_3$)	96%
Magnesium carbonate ($MgCO_3$)	1%
Silica (SiO_2)	2%

The caustic soda works having utilized this limestone since the starting up of the cement plant, the waste used as the lime ingredient contains not over 1% of magnesia.

After careful consideration had been given the results of these experiments by the Michigan Alkali Co., they decided to erect a modern Portland cement plant with sufficient capacity to utilize all the waste product that was then contemplated from Works No. 1.

The design and erection of the plant, together with the process employed, embodies a number of features which will no doubt prove of considerable interest. The plant was erected on the lowland bordering the Detroit River, south of Works No. 1. It was stipulated in the contract for the design and construction of the plant that the materials used should be of the very best quality, and all machinery and apparatus should be thoroughly up to date; that the plant should be made as nearly automatic in operation as possible; and that the latest known devices and apparatus for handling materials and eliminating manual labor as far as possible should be used throughout the construction. The buildings are constructed of steel framework, with brick sides. Clear spans were used throughout the construction in all the buildings, and the trussses are carried on brick pilasters. The roofs of the buildings are covered with slate, which is nailed to 2-in. hemlock sheathing, which in turn rests on the purlins. Owing to the soft nature of the ground, water being found at a depth of 2 ft. from the surface, the brick walls of the buildings were designed to rest on arched foundations. These four-ring brick arches span the bays between the truss lines on the long sides of the buildings and between the pilaster footings on the gable ends. The entire weight of the walls, as well as the trusses are, therefore, carried on the concrete piers from which the arches spring.

The kiln and mill building proper and the stockhouse are constructed in pair, each with a span of 42 ft., while on the north end, occupying in length a space of two bays, are 84-ft. trusses covering the width of the two buildings. Under this part of the building a second story has been provided, constructed of steelwork with brick arched floor, figured to carry a safe load of 600 lbs. per sq. ft. This floor is supported on steel columns which rest on independent footings. The coal grinding department, boiler house and engine room are housed under the same building, having a 50-foot span, but partitioned off with brick walls, as shown on the accompanying plan. Connected with the main building on the north end and running at right angles towards the river, is the clay building, having a 30-ft. span, and constructed of steel covered with galvanized corrugated iron. The machinery for preparing the raw material is erected partly on the second floor and partly on the first floor of the end of the building, having an 84-ft. span.

The waste material is transported to the mill by the use of a traveling crane, which runs into the soda plant, secures a charge and then conveys it by way of the trestle, into the second story of the cement plant, entering at the north end. The clay is excavated close to the mill from the deposit occurring along the bank of the Detroit River, and is hauled in cars to the clay storage building. The clay excavated from the deposit contains a percentage of uncombined silica in the shape of small pebbles. It undergoes, however, no washing, and is treated in the raw state, as there is a slight deficiency in the combined silica, and suitable means are taken to disintegrate these coarse particles in order to raise the percentage of silica. The clay is first handled in the storage building by a conveyor and disintegrator combined, which after breaking up the lumps discharges it into an elevator, which in turn raises and spouts it into a rotary dryer. In this dryer the clay is subjected to the direct heat from the coal flame and after passing out, contains less than ½% of moisture. The dryer discharges the clay directly into a Williams mill, where, after being pulverized, it is elevated to the second floor and discharged into steel storage bins ready to be weighed and proportioned.

The residuum or waste material is excavated from the tanks in the caustic soda plant, and without further treatment is carried in the wet state directly to the mill by the traveling crane, which discharges it into a main receiving tank on the second floor, where it is weighed and the correct portion of clay by weight also added, in order to form the raw mixture. This raw mixture then passes to a long pugmill located on the second floor, where the water is added and preliminary mixing takes place. From here it is discharged into a tank located directly under the floor and supported above the first floor by steel columns. This tank is provided with agitators, which thoroughly mixes the two ingredients and keeps the slurry in a constant state of agitation before being passed into and through the tube mills, where it is ground so that 95% will pass a 200-mesh sieve.

The slurry is discharged from the tube mills into the large concrete tanks constructed below the floor line, and also containing agitators. These tanks are so arranged that material having a high percentage of lime can be ground and discharged into one of the three pits. Should the mixture contain a low percentage of lime, it is discharged into another pit. In the meantime the material is carefully analyzed and afterwards pumped into four large steel circular tanks, located in the second story. The pits are so connected by a piping system that the necessary amount can be pumped from any one pit up into the iron tanks, or the slurry can be pumped from two pits in order to form a correct mixture. In these steel circular tanks, the slurry is stored ready for burning in the rotary kilns. Each tank is provided inside with a frame agitator fitted with blades which revolve on a central shaft. This prevents the clay from settling down in the bottom of the tanks before being used. The system of piping from the steel storage tanks in the second floor is so bypassed that the material is either pumped directly into the rotary kilns or pumped into the standpipe which is connected with the storage tanks, and by which a constant head is maintained in the flow of the material into the kilns.

The wet material, after passing through the piping, is discharged into the kilns through water-jacketed troughs, built into the kiln flues, and extending down into the rear end of the kilns. The kilns are the ordinary rotary kilns, 60 ft. long by 6 ft. in diameter, and lined with a 6-in. ring of aluminous fire brick. As the material flows down through the kilns, the moisture is expelled and the slurry is burned to a clinker by the intense heat generated from the combustion of pulverized coal mixed with air.

The clinker is discharged from the kilns and falls into a large hopper-shaped concrete pit, at the bottom of which an elevator is located; this raises the clinker and discharges it into a specially-designed cooling bin. This bin, constructed of steel, is 12 ft. in diameter, and has a height of 22 ft. In the interior are constructed a succession of metal floors. Extending up the center of the bin is a shaft to which is attached scraper arms located on the level of each floor. These floors have one radial opening extending from the center to the circular shell of the cooler, and the material discharging on the topmost floor or staging is carried around by the scraper arms and passes through the radial opening to the next floor below. Here it is picked up in turn and carried around 350 degrees, and discharged in turn through the radial opening on this floor to the next floor below, and so on until the clinker passes to the bottom of the cooler.

Air is brought in from the bottom and passes up through the cooler by circulating through each floor level. This cool clinker is drawn from the bottom of the cooler and elevated and discharged directly into steel bins located over the top of and feeding the battery of ball mills. After passing through the ball mills, the material is discharged into a conveyor located directly underneath, which carries it to an elevator, from where it is raised and discharged into the conveyor which feeds the bins located over the battery of tube mills.

After final grinding in the tube mills, the cement is elevated and carried by an overhead conveyor across the mill room and through the brick wall which separates the stockhouse from the mill room, discharging directly into the series of overhead conveyors, which rest on top of the self-contained timber storage bins. These transverse conveyors are so arranged that material can be spouted into any bin in the stockhouse. The bins are arranged in two rows, having hoppered bottom floors constructed with a 6-in. layer of concrete on which is laid 2-in. porous brick tile, topped with cement. A passageway runs along the entire length of the stockhouse separating the two rows of bins, in which are located two lines of screw conveyors. These conveyors lie close to the front wall of each row of bins. The material is discharged through adjustable iron doors directly into the screw conveyors, which carry it to the end of the stockhouse, where it is elevated and discharged into the bins for supplying the packing machinery located in the packing-room.

In the packing department, which is located on the first floor under the end of the building having the 84-ft. span, sufficient space has been provided for storing empty bags, as well as cement in packages ready for shipment. The loading platform, located alongside the stockhouse and packing-room, is covered by a steel shed which extends over the roof of the cars standing on the siding. Provision has also been made to load wagons from the platform, located at the extreme end of the building, and which is also one side of the packing-room. This platform is also covered by a steel shed to protect the cement while being loaded.

The track supplying the coal for both boiler and kiln purposes is located on the east side of the building. The coal for the kilns is discharged from the cars, and by the aid of an elevator, raised and passed into a rotary dryer, which removes within 1% of the total moisture; it is then ground in a tube mill and discharged into a large steel storage bin having a capacity of three car loads. From this bin a conveyor carries it directly to the small bins which feed the kilns. The coal is forced into the kilns by a large pressure blower, after having been pulverized so that at least 90% will pass a sieve having 10,000 meshes to the square inch.

The boiler-room contains three 250-HP. Babcock & Wilcox water tube boilers, set one single and two in battery. One 60-in. stack located between the setting serves the three boilers. The engine-room contains one 600-HP. tandem compound condensing engine, together with the heater, boiler feed pumps, hot well and jet condenser, all of which are located along the wall between the boiler and engine-room. The water supply is obtained from the Detroit River and as shown on the plan; the water from the jet condenser passes into a hot well; from there a portion of it is pumped through the heater, and thence into the boilers. An overflow pipe connects the hot well with the 12-in. sewer, located under the floor of the boiler-room, which carries off the excess water. The piping layout is by-passed, so that the engine, if required, can be run non-condensing. The engine is belted directly to the main line shaft and as the engine-room extends slightly over into the mill room proper, this shaft, which is located along the party wall in the kiln and mill room 4 ft. above the floor line, passes through the entire width of the engine-room. This construction brings the drive from the engine to the main line shaft inside of the engine-room, thus preventing the mill dust from entering the engine-room. From the main line shaft the power is taken off at various places and transmitted by leather belts to the various machines throughout the plant, with direct drives or by the aid of countershafts. The only rope drive in the plant furnishes power for operating the packing machinery. This drive is a short single strand one, running from the main line shaft in the mill building proper to a counter overhead, thence through the wall into the packing-room. The shafting is so arranged throughout the plant that the power can be cut out from any department by the use of clutches.

All shafting, as well as the bins, are supported on either concrete piers or steel framework, and with the exception of the bins in the stockhouse,

ENGINEERING NEWS
AND
AMERICAN RAILWAY JOURNAL.

Entered at the New York Post-Office as Second-Class Matter.
Published every Thursday
at St. Paul Building, 220 Broadway, New York, by
THE ENGINEERING NEWS PUBLISHING COMPANY

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ALFRED E. KORNFELD, New York,
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N. B. READ, Boston,
C. F. WALKER, Cleveland,
} ADVERTISING REPRESENTATIVES.

PUBLICATION OFFICE, 220 BROADWAY, NEW YORK.
CHICAGO OFFICE, 1636 MONADNOCK BLOCK.
BOSTON OFFICE, 170 SUMMER ST.
CLEVELAND OFFICE, OSBORN BUILDING.
LONDON OFFICE, EFFINGHAM HOUSE, 1 ARUNDEL ST., STRAND.

SUBSCRIPTION RATES: United States, Canada and Mexico, One Year, $5.00; *6 months,* $2.50; *2 months,* $1.00. *To all other countries in the Postal Union: Regular Edition, One Year,* $7.00 (31 *shillings*); *Thin Paper Edition, One Year,* $6.31 (28 *shillings*). *SINGLE COPIES of any number in current year,* 15 *cents.*

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We desire to call attention to the illustrated description of the Mt. Prospect Laboratory of the Brooklyn Water-Works, by Mr. Geo. C. Whipple, given elsewhere in this issue. In design, equipment, variety of work called for and accomplished and importance of results obtained, this is one of the notable water-works laboratories of the world. The many sources of supply drawn upon by Brooklyn, including surface water, shallow and deep wells, together with the rich and varied organic life in some of the reservoirs, and the numerous studies of materials used in the construction and operation of water-works, all combine to make the work of this laboratory unique. Therefore we have with great pleasure availed ourselves of the opportunity to place before our readers Mr. Whipple's paper, recently presented to the Engineers' Club of Brooklyn. The original paper was accompanied by many lantern slides, but our illustrations are necessarily few. We trust many, or all the slides, or their originals, will be reproduced in the proceedings of the club.

The time is not far distant, we trust, when every water-works in the country will have at its command a well-equipped laboratory for the chemical and biological examination of water, and for other pertinent investigations. The larger works will often find it most advantageous to have such laboratories entirely in their control, although under a properly organized system of municipal government equally good results might be obtained in a general municipal laboratory. For the smaller towns a general laboratory may be both necessary and advisable. Here water, milk and certain other foods may be examined, cultures made to aid in the diagnosis of diphtheria and tuberculosis, blood tested to determine whether or not patients have typhoid fever, and a variety of other work more or less closely connected with the health department may be carried on. The importance of such investigations is beginning to be appreciated, although comparatively few municipalities have yet made suitable provisions for conducting them. These lines are only a beginning, however, of the work awaiting the trained investigator. The time is coming when every progressive and well-governed city will have all its municipal supplies tested to determine whether they come up to the standard, besides requiring a vast amount of work to aid in fixing the various standards. Most city engineers are familiar with cement testing laboratories, but very few have a properly-equipped one at their command, while fewer still have proper appliances for testing any of the other materials entering into paving work. Outside of these lines it is a rare thing to hear of a city that has any sort of equipment for testing its various supplies. Mr. Whipple tells how coal is tested at the Mt. Prospect Laboratory, and in our issue of March 22, 1900, we published a paper by Messrs. Whipple and D. D. Jackson (also read before the Brooklyn Engineers' Club) describing some very interesting tests of "The Action of Water on Asphalts."

THE RAW MATERIALS FOR THE MANUFACTURE OF PORTLAND CEMENT.

The use of lime waste from a caustic soda plant in the manufacture of Portland cement, as conducted by the Michigan Alkali Co., is described at considerable length elsewhere in this issue. As another successful attempt to adapt the waste materials of manufacture to useful purposes this plant is naturally of general interest to the industrial world. To cement manufacturers and users it is more particularly noteworthy, however, as a stride in advance in the adaptation of new varieties of raw materials to their purposes. So far as we know, the works described are the first in the United States to use the lime wastes from soda manufacture in making Portland cement, although this material has been employed abroad for that purpose in several instances. In the kind of raw materials used, therefore, the Portland cement works of the Michigan Alkali Co. stand distinctly alone among the cement works of this country.

From certain points of view, perhaps, there is nothing noteworthy in the fact that the lime wastes from soda manufacture should be found available for making Portland cement. Theoretically, any material or combination of materials which contains the proper proportions of lime, alumina and silica free from deleterious substances will make Portland cement, but commercially the range of possible raw materials for cement manufacture is considerably more restricted. There is not so much danger of this fact being overlooked at the present time, when the technology of cement manufacture has become pretty well established in this country, as there was a few years ago when the industry was just beginning, but it may not be without value to those who have not had occasion to follow such matters closely to discuss briefly the qualities and conditions which make any raw materials commercially and practically suitable for cement manufacture.

Portland cement is a compound composed chiefly of silicates and aluminates of lime, and necessarily the raw materials from which it is made must contain lime, alumina and silica. As they are employed in practice they actually do contain several other substances besides these, the principal ones being iron, magnesia, and sulphuric and carbonic acid. Of these less important substances the iron, in the form of an oxide, probably has a cementitious value, and in some classes of cement the sulphuric acid also plays a role, although when it exists in a greater proportion than 2% it is considered objectionable, if not dangerous. It is generally considered, however, that the magnesia performs no useful function at all and may, when present beyond a certain very small percentage (5% is considered to be the allowable maximum) be dangerous. Mixed with these principal ingredients there are generally present also small percentages of alkalies, organic matter and water. These are impurities. Most of these substances named reappear separately or combined in the cement, but not often in the exact proportions in which they exist in the raw materials. This is due partly to the combination of some of the chemicals contained in the fuel used in calcining and in the lining of the kilns with those contained in the raw materials.

It is not often that nature furnishes a material which contains all of the substances named in the proper relative proportions to make it a suitable raw material for manufacturing Portland cement. The manufacturer then has to get the required combination by mixing two or more materials, each of which furnishes a part of the required constituents. Sometimes one of the materials employed may contain nearly enough of all the requisite substances and very little of another material will have to be added to produce the proper admixture. In other cases one material may furnish the lime only which is required, and the others will be called upon to provide all the silica and alumina. Between these two extremes there may obviously be many practicable combinations.

The mixture of the two raw materials is always a mechanical one, and it must also be an intimate and homogeneous one. If the latter were not the case the chemical combinations which should occur during calcination, and which depend entirely for their successful accomplishment upon the close physical juxtaposition of the different elements, would fail to be carried out properly. For an illustration it will be readily seen that if a lump of chalk and a lump of clay are calcined side by side the conditions are very unfavorable for the silica and alumina in the clay to combine with the lime in the chalk. On the contrary, if we grind the two lumps together to a fine powder and then mold the powder into a brick with water, the three elements are in the very best physical relation to each other to combine chemically when the brick is calcined.

The mechanical mixture which has been described is the standard mixture from which Portland cement is manufactured. Any two or more natural materials may, therefore, be used for making the standard mixture providing they contain the requisite chemical constituents in the proper proportions. Thus we find at one extreme soft chalks and clays, and at the other extreme hard limestones and shales successfully employed in making Portland cement. The range of choice of raw materials is a wide one physically. Chemically a considerable latitude is also allowed by the fact that the formula for the chemical composition of Portland cement varies as the manufacture of this material is actually carried out. An analysis of 45 French, English, German and Belgium cements given by Candlot in "Ciments et Chaux Hydrauliques," gives the limits of variation shown in Table I., to which has been added a similar record of analysis of eleven American Portland cements.

This table shows that the standard mixture may vary in silica from 19.92 to 26.1%, in alumina from 5.20 to 10.6%, in oxide of iron from 2.10 to 4.95%, in lime from 59.1 to 67.31%, in magnesia from 0.26 to 3.53%, and in sulphuric acid from 0.26 to 4.25%, and still be suitable for manufacturing Portland cement. These figures, it must be understood, are the results obtained from the analysis of a limited number of cements, and do not by any means establish or show standard limits of variation. They serve, however, to illustrate the latitude permissible in the chemical composition of the standard mixture of raw material.

While the range of raw materials from which Portland cement can be manufactured is a somewhat broad one, as shown above, it must not be assumed that all such materials are equally valuable for this purpose. It is plain that the more nearly pure the various materials are the better suited they are for cement manufacture. It is clear also that deposits which run nearly uniform

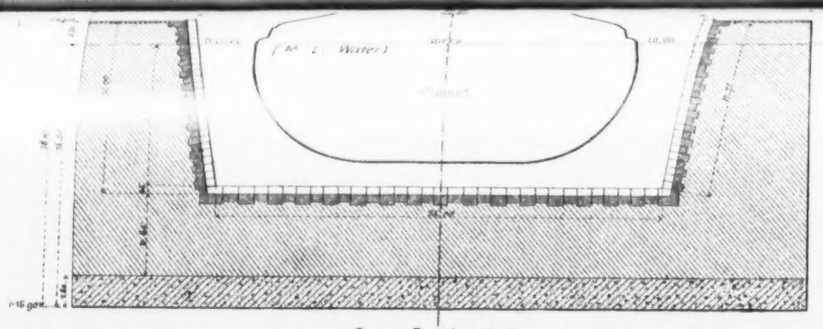
TABLE I.—Showing the Chemical Composition of Representative Foreign and American Portland Cements.

Constituent.	French.	English.	German.	Belgian.	American.
Silica, %	21.70 to 24.90	20.3 to 24.05	20.8 to 24.85	23.8 to 26.1	19.92 to [illegible]
Alumina, %	5.20 " 8.33	6.30" 9.73	5.25 " 10.6	5.33 " 8.51	6.16 " [illegible]
Oxide of iron, %	2.10 " 3.87	2.67" 4.30	2.40 " 4.04	2.51 " 3.47	2.35 " [illegible]
Lime, %	59.1 " 67.31	59.8 " 62.72	61.04 " 67.18	60.03 " 64.12	60.32 " [illegible]
Magnesium, %	0.58 " 2.20	0.33" 1.07	0.90 " 2.30	0.70 " 0.88	0.75 " [illegible]
Sulphuric acid, %	0.26 " 2.23	1.45 " 4.25	0.37 " [illegible]	0.74 " 1.54	0.79 " [illegible]

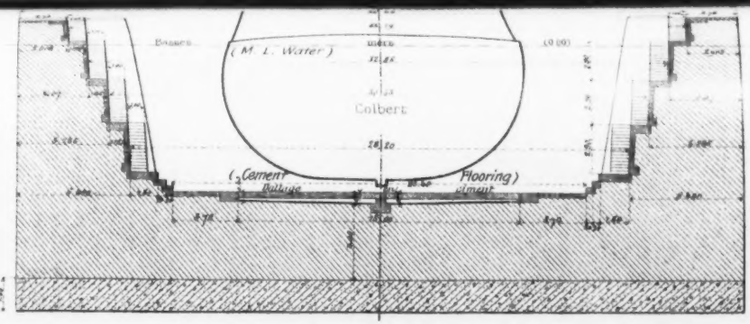
BETWEEN CAISSONS.

Transverse Section.

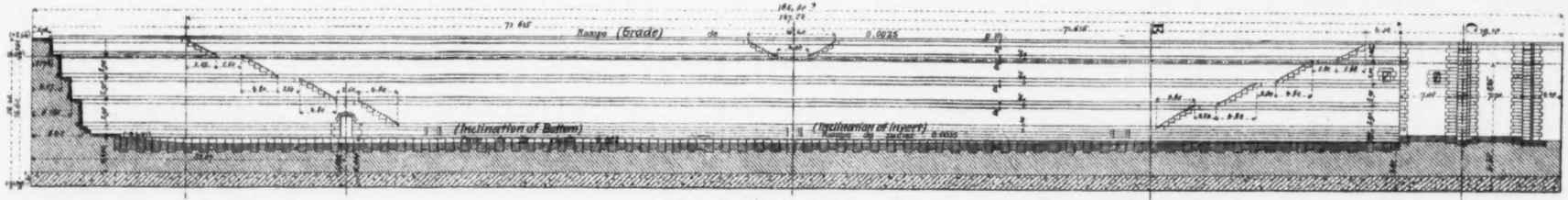
FIG. 1. PLAN AND SECTIONS OF PNEUMATIC CAISSON.



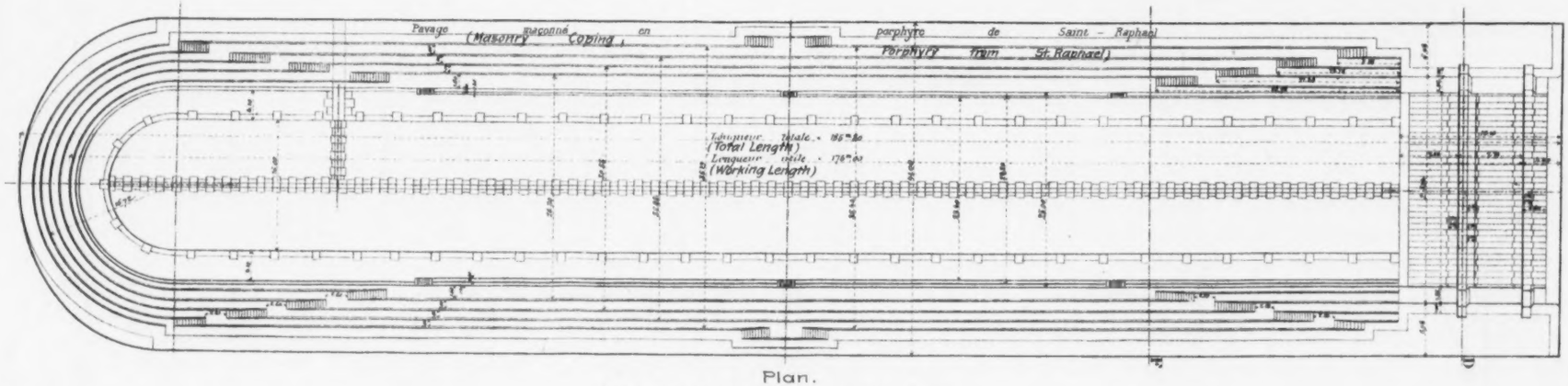
Cross Section C-D.



Cross Section E-F.



Longitudinal Section.


Pavage maçonné Coping en porphyre de Saint - Raphael
(Masonry Coping of Porphyry from St. Raphael)
(Total Length)
(Working Length)

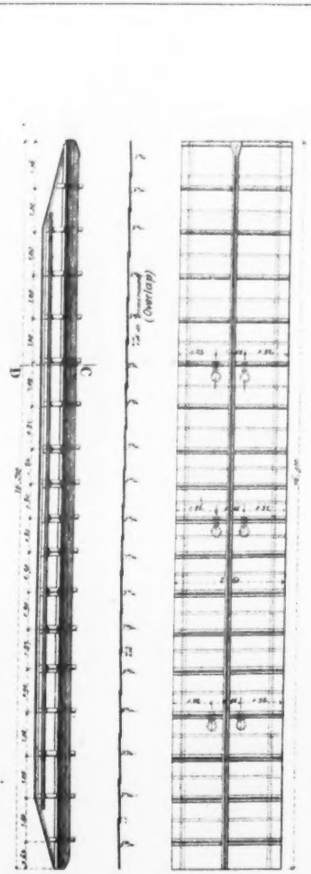
Plan.

FIG. 2. PLAN AND SECTIONS OF MASONRY.

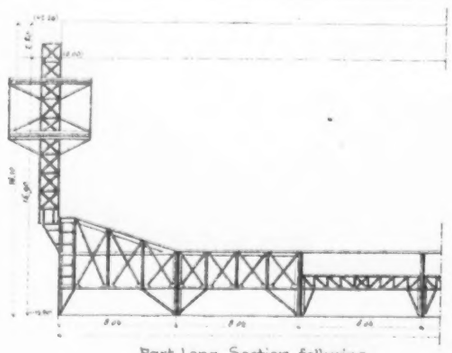
DRY DOCK WITH PNEUMATIC CAISSON FOUNDATION AT TOULON, FRANCE.

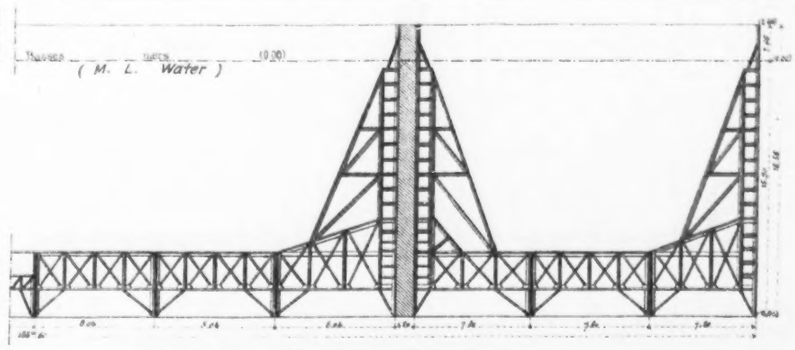
Mr. Herrent, Paris, France, Contractor.

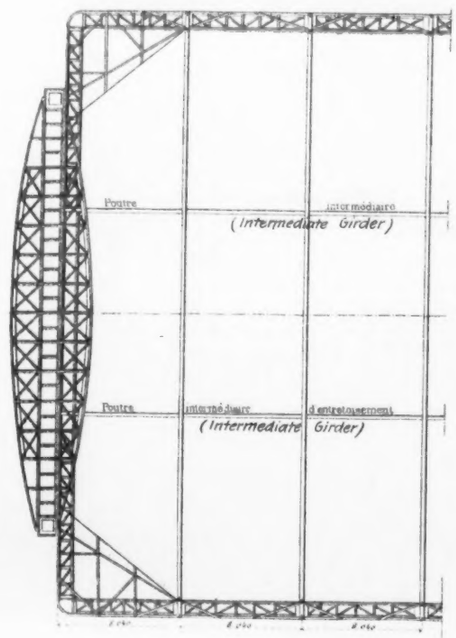
CHAS. HART, LITH., 88 VESEY ST., N. Y.

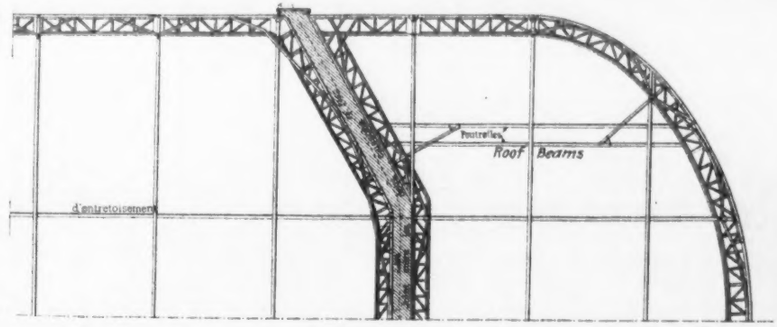


DETAILS OF COVER FOR JOINT BETWEEN CAISSONS.









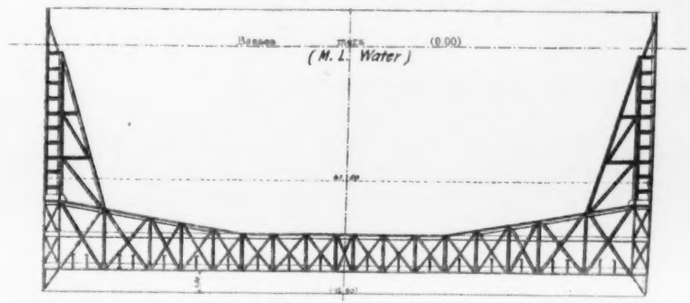


FIG. 1. PLAN AND SECTIONS OF PNEUMATIC CAISSON.

position are preferable to ones which ... derably in this respect from time to ... further that materials which are easily ... reduced to form the standard mixture ... than those which require a greater expenditure of labor and money.

The ... statements are equally true whatever ... process followed in the manufacture. The proper ... ture of the raw materials, as already ... requires that they shall be reduced to ... intimately mixed. In the wet process ... ufacture a chalk and a clay which will ... and quickly dissolve in the mixing ... better than ones which take a longer ... more work in reduction. Similarly in the dry process these limestones and shales which are ... easily ground to the proper degree of ... better than those which are more intractable. This illustration and comparison may obviously be carried to all the other operations necessary to produce the mechanical mixture required, but it is plain from what has been said that satisfactory deposits of raw material for the manufacture of Portland cement may be rather difficult to obtain, when we consider the matter of cement production from a commercial point of view, notwithstanding the apparent latitude in selection which seems otherwise possible. The object to be sought in selecting raw materials is not merely to produce a standard mixture approximating a certain chemical compositon, but to do it as economically as possible.

Bearing what has been said in mind, attention may now be turned to some of the raw materials which are actually employed in making well-known brands of Portland cement. Table II., rearranged from tables given in "The Mineral Industry, 1898," and elsewhere, shows the chemical composition of a large variety of American, English, German and other raw materials. The analyses given are in most cases those reported by the manufacturers.

In conclusion it may be noted that the Michigan Alkali Co.'s work in making cement from its waste product is not the only instance in this country of the successful utilization of manufacturing wastes in Portland cement manufacture. At the works of the Illinois Steel Co., in South Chicago, Portland cement is now being made in considerable amounts from an admixture of blast furnace slag and limestone. The use of blast furnace slag for making slag cement has been practiced for a long time abroad, and also to a less extent in America, but this works is, so far as we know, the only one in which that material is used in making a true Portland cement. As illustrating the wide adaptability of the rotary kiln to all classes of raw materials, it is interesting to notice that this device is used by both the Michigan Alkali Co., and the Illinois Steel Co., for calcining their cement.

LETTERS TO THE EDITOR.

Laying Out Transition Curves.

Sir: In W. H. Sadler's letter on transition curves (Eng. News, April 12, 1900), he has given

N = length of curve in chords of 100 ft.

I think this should read

N = length of curve in chords of 10 ft.

The application of his formula (6) to his example to set 10 + 50 would then be:

$$\text{Def. in min.} = \frac{19 \times 6 \times (5.4)^2}{300} = \frac{1,749.6}{300} = 5.832.$$

In canyon and very rugged work it is often impossible to set the P I, and the whole curve with spirals can then be run by the use of the following formulas, in which,

C = length of subchord of spiral in feet, and

d = distance from P S in feet. (Point of spiral.)

Leaving tangent

$$\text{Def. in mins.} = \frac{d^2}{10\,C} \text{ (Original.)}$$

Leaving simple curve, toward tangent,

$$\text{Def. in min.} = D \times d - \frac{d^2}{10\,C} \text{ (Original)}$$

in which D = rate of deflection of curve already run.

Example.—Given P S of 5° curve for 20° 00′ = 95 + 50 (40-ft. subchords.)

(10° 00′ — 5° curve.)

95 + 50 P. S.	00′
95 + 90	04′
96	06¾′
96 + 30	16′
96 + 70	36′
97	56¾′
97 + 10	1° 04′
97 + 50 P. C.	1° 40′
99 + 50 P. S.	00′
99 + 90	1° 00′ — 04′ = 56′
100	1° 15′ — 06¾′ = 1° 08¾′
100 + 30	2° 00′ — 16′ = 1° 44′
100 + 70	3° 00′ — 36′ = 2° 24′
101	3° 45′ — 56¾′ = 2° 48¾′
101 + 10	4° 00′ — 1° 04′ = 2° 56′
101 + 50 P. T.	5° 00′ — 1° 40′ = 3° 20′

Leaving simple curve toward one of lesser radius

$$\text{Def. in min.} = D \times d + \frac{d^2}{10\,C}.$$

The number of subchords = D° (Sadler).

F. M. Robinson,
Division Engineer, N. W. & W. R. R.

Bridgeport, Neb., April 28, 1900.

TABLE II.—Showing the Chemical Composition of the Raw Materials Used in Manufacturing Representative Foreign and American Portland Cements.

Source.	Material.	SiO_2, %.	Al_2O_3, %.	Fe_2O_3, %.	CaO CO_2, %.	CaO, %.	MgO CO_2, %.	MgO, %.	Insol., %.	Water & organic, %.
American Materials.										
Lehigh Valley, Pa.	Cement rock	14.68	5.32	1.12	69.26	.....	3.67	.....	.....	1.68
	Cement rock	15.40	4.26	1.38	74.66	.....	2.66	.....	.....	1.88
	Limestone	5.87	1.59		88.00	.....	4.00	.....	.....	.....
	Cement mixture	13.97	5.07	1.88	74.10	.....	2.04	.....	.....	1.82
Lawrence county, Pa.	Limestone	4.14	0.21	1.77	90.47	.....	1.00	.....	.....	2.03
Warren county, N. J.	Cement mixture	14.16	6.64		73.96	.....	3.13	.....	.....	.....
Glens Falls, N. Y.	Limestone	3.30	1.30		.....	52.15	.....	1.58	....[1]	8.37
	Clay	55.27	28.15		.....	5.84	.....	2.25	....[2]	.....
Warners, N. Y.	Marl	0.26	0.10		94.39	.....	0.38	.....	.....	4.64
	Clay	40.48	20.95		25.80	.....	0.99	.....	.....	8.50
Sandusky, O.	Marl	.....	1.72		92.70	.....	0.53	.....	1.28	1.13
	Clay	64.70	11.90	9.90	.....	0.9	.....	0.7	.....	11.90
Bronson, Mich.	Marl	1.65	.....	0.81	90.66	.....	trace	.....	.....	5.56[3]
	Clay	62.10	20.09	7.81	.....	0.65	.....	0.96	.....	7.90[4]
Yankton, S. Dak.	Chalk	2.15	2.72		93.72	.....	.....	.....	.....	.....
	Chalk	8.20	7.07		83.59	.....	.....	.....	.....	.....
	Clay	57.98	18.26	4.57	.....	1.75	.....	1.83	.....	12.08[5]
Arkansas	Chalk	4.42	2.21	1.03	95.29	.....	.....	.....	.....	.....
	Chalk	6.09	3.52	1.20	87.93	.....	.....	1.06	.....	.....
	Clay	53.30	23.29	9.52	.....	0.36	.....	1.49	.....	5.16
	Clay	65.12	19.05	7.66	.....	0.34	.....	0.31	.....	6.12
English Materials.										
English	White chalk—From	0.66	.....	0.35	98.60	.....	0.21	.....	.....	.....
	White chalk—To	1.59	.....	0.74	97.90	.....	0.10	.....	.....	.....
	Gray chalk—From	1.67	0.93	0.38	96.50	.....	0.50	.....	.....	.....
	Gray chalk—To	6.84	1.14	0.46	87.35	.....	0.10	.....	.....	.....
	Cement-slurry	11.77	4.45	2.13	69.97	.....	2.87	.....	1.24	7.59
	Cement-slurry	11.83	5.23	1.97	74.18	.....	1.29	.....	2.53	1.82
	Medway clay	63.66	16.10	6.74	.....	0.81	.....	1.73	.....	3.38
	Tyne clay	55.83	28.04	7.78	.....	.....	2.57	.....	.....	.....
German Materials.[6]										
German	Hamburg chalk	1.55	0.50		97.50	.....	.....	0.19	.....	.....
	Hamburg clay	52.50	17.35	5.75	.....	4.48	.....	3.24	.....	14.00
	Stettin marl	19.70	3.66	1.34	73.92	.....	0.97	.....	.....	.....
	Stettin clay	54.60	18.20	5.40	.....	2.80	.....	3.16	.....	13.10
German	Rhine limestone	3.00	0.42	0.53	94.50	.....	.....	0.86	.....	.....
Belgian	Clay	50.70	19.13	8.37	.....	2.68	.....	3.20	.....	13.40
	Beerse clay	65.50	18.55	6.61	.....	0.38	.....	1.18	.....	.....
	Vise chalk	1.42	0.577		96.80	.....	0.45	.....	.....	.....

[1]Also contains 40.98 CO_2 and 0.30 SO_3; [2]contains 0.12 SO_3; [3]contains 0.66 SO_3; [4]contains 0.49 SO_3; [5]contains 1.28 SO_3. [6]These German materials contain 0.20, 0.94, 0.32, 0.99, 0.13, 1.64 and 0.14 parts SO_3, respectively.

Notes and Queries.

The contractors for the locomotive-erecting shops of the Philadelphia & Reading R. R., described in Engineering News of May 24, 1900, were incorrectly given as the Phoenix Bridge Co., of Phoenixville, Pa. We are informed that this company has simply the sub-contract for the steel work from the general contractors, Ryan & Kelley, of Philadelphia, Pa.

THE WORK OF THE UNITED STATES COAST AND GEODETIC SURVEY.

A brief historical summary of the work accomplished by the U. S. Coast and Geodetic Survey since its inception in 1807 is contained in the 67th Annual Report of the Survey which has just been issued. This summary is a reprint of a report made by Mr. E. D. Preston to the General Conference of the International Geodetic Association held at Stuttgart in 1898. While largely historical in character this report contains a large number of statistics which are usually widely scattered, and we abstract the more interesting of these in the following paragraphs.

The work of the Geodetic Survey was authorized by Congress in 1807; but nothing was done worthy of the name of geodesy until 1832. In that year operations were begun with vigor, and the whole Survey was reorganized in 1843 upon a permanent basis. For 62 years the Survey has been under the Treasury Department, with the direction of the work in the hands of a civilian.

Up to the present time the following work has been accomplished: 350,000 sq. miles of territory have been triangulated; embracing 15,000 stations for horizontal measurements and determining 28,500 geographical positions. The topography work done covers 38,500 square miles; including 11,600 miles of general coast line, 100,000 miles of shore lines of rivers, etc., and 51,000 miles for roadways. The soundings made cover 164,000 square miles of area, besides 93,000 square miles of deep-sea soundings. To record these surveys 4,600 original topographic and hydrographic sheets have been made, from which 1,300,000 charts have been distributed.

Under the head of base lines, the report says that 203 have been measured; and of these 19 are classed as primary, with an average length of 9,892 meters. With the apparatus used for these base lines, the errors of measurement are classed as follows: With the different forms of metallic bars, an error of one-millionth of the length measured; with tape-line, an error of one in two millions; and with a rod packed in melting ice the error can be readily reduced to one in five million. The newest form of base apparatus is devised by Assistant Wm. Eimbeck. It consists of two bars, brass and steel, 5 m. long, and so arranged that the measure can be made with each component separately and simultaneously. The Salt Lake base measured with this apparatus gave results with a probable error of less than one in five million.

Exclusive of Alaska, the shore line of the United States is 5,452 miles long; and this is all covered by triangulation, except a few hundred miles on the northwest coast. An oblique arc of 22° has been measured extending from the northeast boundary of Maine to the southwest limit of Alabama; and an arc of 49° has been measured on the 39th parallel of latitude from the Atlantic to the Pacific. The greatest triangle used has sides of 133, 167 and 190 miles long, and the highest station is 14,000 ft. above sea level.

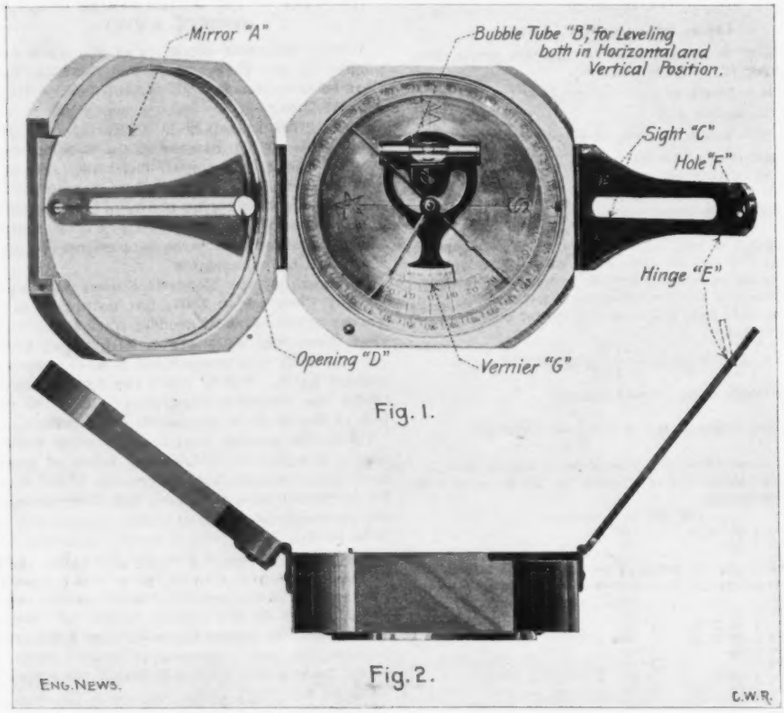
In astronomical work, a list of several thousand stars has been published, based upon special observation. In these the average probable error of a declination is given at rather less than ¼", enabling an observer to determine his latitude, from 20 pairs in one evening, with an uncertainty of only ±10 ft. The Survey has also sent out 35 parties for observation of solar eclipses and transits of inferior planets. The variations of latitude have been determined at three stations, each occupied more than one year.

In precise leveling, 5,000 miles have been executed, including four independent determinations of the height of St. Louis, Mo. Two sets have been run from the Atlantic, at Sandy Hook, to the Gulf of Mexico, at Biloxi. One result of the latter levels is that the surface of the Gulf of Mexico is found to be somewhat higher than sea level at

New York. The spirit-levels are continuous from Sandy Hook to Denver.

Permanent magnetic observations have been made for five consecutive years at Philadelphia, Key West, Los Angeles and San Antonio. The force of gravity has been investigated in the United States and in 28 foreign stations.

The work in progress includes a resurvey of



FIGS. 1 AND 2.—BRUNTON POCKET TRANSIT.

Chesapeake Bay; measurement of an arc on the 98th meridian; and the development of Alaskan topography. It is proposed to extend the great arcs into Mexico and the British possessions, and diplomatic work is now in progress looking towards concerted action.

Geodetic surveys have also been carried on by the U. S. Corps of Engineers. This body completed the survey of the Great Lakes in 1882; it has charge of the Mexican boundary survey and the work done by the Missouri and Mississippi River commissions. The report on the Mexican boundary is already in type, but not ready for distribution. The Missouri River Commission has triangulated from St. Louis to Three Forks, Montana, a distance of 2,551 miles, and covering the valley from bluff to bluff. The Mississippi River Commission has now connected the Gulf of Mexico and St. Paul, Minn., a distance of 1,600 miles.

A SURVEYING INSTRUMENT FOR MINING AND RECONNOISSANCE WORK.

The accompanying illustrations show the general appearance and method of operation of a handy little "pocket transit" particularly adapted for rough surveys and mining work. Fig. 1 shows a view of the face and Fig. 2 a side elevation of the instrument, with lid and sight open. Figs. 3 to 5, inclusive, explain clearly the manner of operating the instrument in actual work.

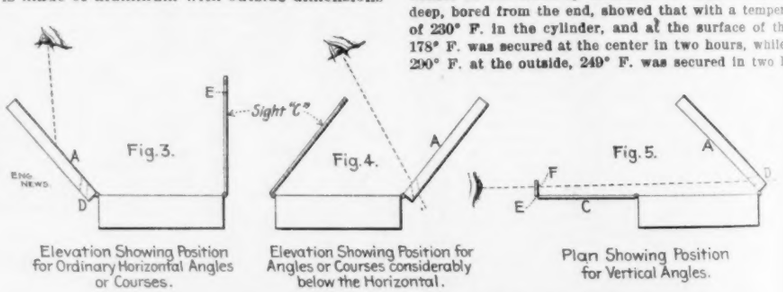
For taking ordinary horizontal courses or angles the instrument is held as indicated in Fig. 3, and, after leveling (the bubble tube B being turned at right angles to the line of right) it is held in such a position that the etched line on the mirror A bisects the reflection of the sight C and the object sighted on.

For horizontal curves or angles where the object sighted is 15° or more below the horizon the best position for the instrument is shown in Fig. 4, where the object is seen through the opening D while the line on the mirror A bisects the reflection of the sight C.

For vertical angles the sight C (Fig. 5) is turned back in line with the face of the compass-box and with its end bent at right angles by the hinge E. The mirror A is set so as to make a 45° angle with the face of the compass-box. The instrument is then held carefully in a vertical plane. The object is sighted through the hole F and the opening D, and while so sighted the bubble tube B is moved by an arm outside the bottom of the compass-box until the bubble centers in the tube; which is readily determined by viewing the reflection of the bubble in the mirror A. The vertical angle is then read from the vernier G.

All these operations may be performed with the instrument held in the hands, though greater accuracy would doubtless be gained by using a fixed support. Various other uses, particularly those of a clinometer and level, suggest themselves. The case is made of aluminum with outside dimensions of 3 ins. in diameter by 1 in. thick, and the whole weighs but 8 ounces.

The "transit" is patented by D. W. Brunton and manufactured by Wm. Ainsworth, Denver, Colo., to whom we are indebted for the opportunity to make a practical examination and test of the instrument.



In the Figures the Instrument is Shown Close to the Eye. In Practice it will be held a Foot or more away, at the Convenience of the Observer.

FIGS. 3 TO 5.—DIAGRAMS INDICATING THE RELATIVE POSITIONS OF THE OBSERVER'S EYE, THE COMPASS-BOX, AND OF THE MIRROR AND SIGHT, FOR THE MORE COMMON OBSERVATIONS.

A PROPOSED METHOD FOR THE PRESERV[illegible]ON OF TIMBER.*

By F. A. Kummer, Jun. Am. Soc. [illegible]

The experiments herein described, and the [illegible] upon which the proposed process has been developed, [illegible] made particularly with a view of improving what is known as the creosoting process, it being believed that this process would command a much more extensive use if certain mechanical difficulties, now met with in connection with its application to timber, and particularly to railroad ties, could be removed. The improvement of this process was also attempted because of its acknowledged merit when properly applied. As at present applied, it possesses certain features which preclude its extensive use in the treatment of railroad ties. If, by a simplification or improvement of the process as now used, the objections hitherto raised to it may be overcome without sacrificing any of the advantages which it possesses, and if, further, this can be accomplished at no greater cost, the resulting process would commend itself to engineers generally.

The writer will first give the reasons for the decay of timber, and state exactly what steps should be taken to prevent this decay. Having done this, he will analyze the dead oil of coal-tar process as at present used, and see whether these necessary steps are carried out properly.

There are two causes for the decay of timber. Through the fermentation of its contained sap, such fermentation being caused by the germs contained or developed in the sap. (2) Through the introduction of germs of decay from without, through the action of air or water.

To treat a tie satisfactorily, it must first be sterilized throughout; removing at the same time as much of the contained moisture as is possible without injury to the fiber of the wood. Fermentation cannot then take place from within. It must then be treated in such a manner that germs of decay cannot enter from without, or, if they do enter, that the conditions for their development are highly unfavorable. It must further be provided that the antiseptic injected will not be dissipated through any agency, and, if the timber is to be subjected to the crushing effect of heavy railroad traffic, it must in some way be provided that the timber so protected will be able to resist the weights which will pass over it, without excessive crushing.

If a tie be subjected throughout to a sterilizing temperature of 212° F., the agencies of fermentation or decay existing in the sap will be killed, and, if prevented from again entering the timber from without, decay cannot take place. This leads to the first important conclusion; namely, that complete sterilization throughout is a necessity in the treatment of timber. Without such sterilization no form of treatment can be satisfactory unless the timber be completely impregnated throughout its entire mass with an antiseptic material, which is rarely if ever accomplished with large timber. Such sterilizaton means fully 212° F. at the heart of the stick. Wood is a poor conductor of heat, and, to secure 212° F. or more at the heart, two ways are open: (1) long exposure to a temperature of say 215 to 225° F., which is expensive because of the time consumed; (2) exposure to a temperature of 290 to 300° F., which, under ordinary conditions, will injure the fiber of the wood, or at least induce extensive splitting or cracking. The necessity for sterilizing is not brought out in the creosoting process, and it seems to be a point, the vital nature of which is not generally recognized. Experiments made upon yellow pine ties, 6 ins. × 8 ins. × 8½ ft., having self-registering thermometers imbedded at the heart by means of an auger hole, 24 ins. deep, bored from the end, showed that with a temperature of 230° F. in the cylinder, and at the surface of the tie, 178° F. was secured at the center in two hours, while with 290° F. at the outside, 249° F. was secured in two hours.

Starting with sterilization as an absolute necessity, it is evident that, if such a temperature as 290° F. can be used without injury to the timber, complete sterilization will be effected, and in a reasonably short time. It would be well to state here that, with a few exceptions, the experiments

*Condensed from a paper read before the American Society of Civil Engineers on June 6, 1900.
†11 Broadway, New York, N. Y.

long-leaf yellow pine of the best merchantable grade, the exceptions being several experiments upon [illegible] timber, which showed that it is not capable of such a process, owing to its great tendency to crack under high temperatures.

[illegible] adopted to render the use of such high temperatures possible in the treatment of yellow pine is the application of pressure simultaneously with the application of heat.

When the doors are closed the heat is raised to 212° F. without pressure, taking one hour to accomplish this, and kept for one hour at 215° F. without pressure. This is for the purpose of getting rid of the moisture. When the heat is increased, pressure is applied, and both are increased gradually to avoid injury to the fiber, for example, until the heat has reached about 285° F. and the pressure about 90 lbs., and both are held there for one hour. The heat is then shut off, and the tanks are allowed to cool gradually for one hour. At the end of this time the heat is reduced to 250° F. and the pressure to about 60 lbs. The pressure is then blown off and the heat still further reduced. Vacuum is then applied until about 26 ins. is reached, and while under vacuum the mixture is run into the cylinder at a temperature of 175 to 200° F. and hydraulic pressure applied reaching 200 lbs. per sq. in., and kept at this point until the desired amount of the mixture is absorbed. The liquid is then run off, and the wood is placed in another cylinder, and milk of lime at a temperature of about 150° F. is run in, and hydraulic pressure of about 200 lbs. is applied for from one-half to one hour. The following is a condensed table of the treatment: 1 hour to reach 215° F.; 1 hour under 215° F.; 2 hours (heat and pressure applied gradually) to reach 285° F.; 1 hour (90 lbs. pressure) at 285° F.; 1 hour cooling; 1 hour vacuum (26 ins.); ½ hour filling cylinders with mixture; 3 hours pressure (average 8 to 10 lbs. absorption); ½ hour emptying tanks; and 1 hour under lime and pressure treatment.

The time will be increased or decreased, in keeping with the amount of absorption required.

The treatment of "green" lumber herein mentioned consists of simply putting the lumber in the cylinders and raising the heat to about the temperature of the liquid—say 200° F.—and then running the liquid in and keeping it there from three to four hours. Of course, this does not sterilize it or give as good absorption.

After the preliminary treatment, the temperature of the interior of the cylinder is raised to 285 or 290° F. If this temperature were maintained at atmospheric pressure, not only would the sudden and rapid evaporation of the remaining moisture in the stick induce splitting and cracking, but the volatile oils in the wood would be driven off, and this is not desirable, inasmuch as they play a not unimportant part in the preservation of the timber. Air pressure is therefore maintained in the closed cylinder at about 80 to 90 lbs. per sq. in., so that while the tie is sterilized by heat, the natural oils are not driven off, and splitting and cracking does not result, while the heat is at the maximum.

One of the benefits of the vacuum is to exhaust the air which has been forced in while the wood was under pressure, and which, if not removed, would have to find its way out subsequently either through the mixture or by creating cracks.

Mr. J. W. Putnam, in a letter to Octave Chanute, M. Am. Soc. C. E., Chairman of the Committee on the Preservation of Timber, in 1885, wrote as follows:*

The most carefully conducted experiments indicate that there is no decay without fermentation, and no fermentation without germs. If a piece of timber be cut green and thoroughly coated with paint, it will soon be destroyed by what is called dry rot. If a similar piece be heated through to 225° F., and a sufficient amount of oil be forced in to form an impervious coating, no decay will take place until that coating is broken.

This not only evidences the necessity of complete and thorough sterilization, but brings us to the next step in the process, the impregnation of the timber with the antiseptic material. Having thoroughly sterilized the tie, the natural continuance of the process is, of course, the application of the vacuum, to remove from the pores of the timber the air or vapor which they contain and admit the preservative fluid under this vacuum.

The preservative fluid used is not creosote, or dead oil of tar alone, but consists of dead oil of coal-tar, 38%; formaldehyde, 2%; and melted resin, 60%, by weight. The specific gravity of the resulting mixture at 300° F. is 1.068. The resin is used to render the mixture absolutely waterproof, the formaldehyde to strengthen the antiseptic nature of the compound, necessarily somewhat reduced by the reduction in percentage of the dead oil itself.

This mixture is perfectly fluid at 300° F., and, by some peculiar action not readily explainable, seems to be more readily forced into the wood than the creosote oil alone. There are a number of very important advantages gained by the use of the resin in connection with the dead oil. Timber treated by the ordinary creosoting process is more or less spongy and soft, and while the dead oil is not generally regarded as soluble, it is still subject to dissipation by the action of water, as is well known in the case of treated piles subject to the washing action of salt water. Experiments made by immersing in water timber untreated and treated by the process just described, showed results as follows:

*"Transactions," Am. Soc. C. E., Vol. xiv, 1885, p. 337.

One piece creo-resin timber, 6 ins. × 8 ins. × 8 ft., immersed in water 27 days, absorption 1¾ lbs. One piece, same stick as above, untreated, absorption 11¼ lbs. The increase in weight of the first stick was largely due to water clinging to the surface.

Timber treated with dead oil in conjunction with resin is practically absolutely waterproof and very much harder than the untreated timber, instead of being softer and more spongy, as is the case with creosoting proper. The introduction of bacteria from without should be prevented by a process as highly waterproof as it is possible to make it, and this process should use a material which will not only have these waterproof qualities, but will be so antiseptic in nature that the possibility of the existence or development of decay germs, if such germs by any means gain an entrance into the timber, should be reduced to a minimum. In fact, the conditions should be such as to absolutely preclude any possibility of their life or development. To secure these results, the combination of resin, creosote oil and formaldehyde is especially well adapted. The material weighs about 8.9 lbs. per gallon.

Experiments were made upon pine ties cut in two, one half vulcanized, the other half not vulcanized. The results are given in Table I., and show the difference in absorption.

TABLE I:—Showing Comparative Absorption of Green and Vulcanized Pine Railway Ties.

	Maximum Heat.	Pressure in lbs.	Lbs. per cu. ft.
Green	285°	90	3.33
Vulcanized	285°	90	6.5
Green	275°	80	7.14
Vulcanized	275°	80	10.66
Green	285°	85	3.43
Vulcanized	285°	85	6.18
Green	270°	80	6.75
Vulcanized	270°	80	9.45
Green	275°	90	5.22
Vulcanized	275°	90	7.9

These specimens were treated with various degrees of heat and pressure, with and without vacuum, and in all cases they showed an increased absorption in the vulcanized over the unvulcanized timber.

As regards the spongy condition of the wood, after treatment by the creosoting process, an inspection of timber treated by the proposed process readily demonstrates that timber is not in any way softened. The surface is subjected to treatment by the application of milk of lime after the creosote-resin has been injected. This tends to solidify the mixture of resin and creosote oil. Solidification to a point of brittleness is not effected, but solidification is effected to such a degree that the resulting surface of the wood is materially harder than that of untreated timber, instead of being softer, as is the case with creosoted timber. The writer has made tentative experiments to prove this hardening effect by striking treated and untreated sections of the same tie with a hammer. The greater density and hardness of the surface of the creosote-resin tie (about 50% increase in density near the surface) being readily apparent from the way in which it resists crushing under the hammer, the force of the blow causing the hammer to rebound from its surface instead of sinking in and crushing the fiber, as was the case with the untreated portion of the same tie.

Obviously, if it were commercially practicable to impregnate a railway tie, of, say, long-leaf yellow pine, throughout its mass with creosote oil, no decay would take place in the timber so long as the oil remained in it. But such a treatment is impracticable, both because of its cost, and of the mechanical difficulties attending it. We, therefore, are obliged to fall back upon the plan, to secure complete sterilization, and then to inject sufficient of the preservative effectually to protect the remainder of the stick. This may be done by the injection of 8 to 10 lbs. per cu. ft. in a standard-sized tie, 8 lbs., giving a penetration averaging at the center of the tie about ¾ to ⅞-in., and 10 lbs., ⅞-in. to 1¼ ins. at the center, with from 6 to 8 ins. inward from the ends of the stick in each case.

A tie treated by the above process, with, say, 10 lbs. of preservative per cu. ft., possesses these advantages: It is thoroughly sterilized—a result not generally secured by the creosoting process: the outer fibers of the wood are filled with a material more highly antiseptic than dead oil of coal-tar, practically waterproof, and, when hard, considerably better able to resist crushing or cutting than is either the untreated or the creosoted timber. In fact, the spongy nature of creosoted timber, especially as the timber usually chosen for creosoting is naturally soft, has been one reason why creosoted timber has not been more extensively used under heavy traffic. The experience of the Lehigh Valley R. R. was along this line. A tie treated by the process in question also possesses much higher spike-holding qualities—considerably higher than the untreated stick.

The writer has confined these remarks particularly to the subject of railway ties; but it should not be overlooked that a large part of the business done by the creosoting works at present is upon piles and dock timbers; and the failure of such timbers when attacked by the teredo is invariably due to the washing out of the creosote oil by the action of the salt water. It would, therefore, be readily practicable to creosote piles, giving them either at the same time, or subsequently, a resin treatment to absolutely retain the creosote in the wood, and therefore the chief objection to creosoted piling would be at once removed.

The question of wooden paving blocks is also one having, in the writer's opinion, great possibilities. Wooden paving blocks, creosoted, are in extensive use in London and continental cities, and have given very favorable results in this country wherever properly used. If we add to the preservative effect obtained by the creosote oil the additional and most important benefit of so hardening the fibers of the wood that its resistance to wear is materially increased, we have realized a most material gain in the treatment of such blocks. In fact, if a treated pine paving block, protected against decay by dead oil of coal-tar, impervious to moisture and having considerably greater density and resistance to abrasion than either the creosoted or untreated timber, can be laid at a cost not greater than that at present charged for asphalt, it is the writer's opinion that such a pavement will possess all the advantages which asphalt possesses, and will be at the same time both noiseless and not slippery; thus removing two of the gravest objections to asphalt pavement. The writer thinks that such a pavement would have a longer serviceable life than asphalt—at least such as is generally laid—and on streets of a certain class be exceedingly desirable.

To revert once more to the question of tie preservation: With creosoting, as well as with the proposed improved process, the amount of impregnation per cubic foot is regulated by the specifications under which the work is done. For railroad ties the general practice is about 10 lbs. Whether pure creosote or creosote and resin are used, this specification gives a depth of penetration at the center of the tie averaging nearly 1 in., and at the ends of the tie a complete penetration from the end of the tie of from 8 to 10 ins. Both with creosoting and with this process, the depth of penetration depends not only upon the amount of material injected per cubic foot, but also upon the nature of the timber and upon the individual qualities of different sticks of the same kind of timber. The writer has suggested as a possible disadvantage to such processes—whether creosoting or improved creosoting—the likelihood of the splitting of the tie taking place after treatment, thus allowing the introduction of germs into the heart of the stick. A careful examination and sawing of some 15 to 20 ties, treated for periods extending up to six months, has shown no instance in which new cracks had opened in the timber and extended beyond the treated portion of the tie. Should this be the case after several years' service, the writer believes it to be true that the vulcanized heart of the tie treated by the improved process would better resist the action of decay than the untreated and unsterilized heart of the creosoted timber.

Further, it seems probable that water containing germs would to some extent get rid of such germs in passing through that portion of the timber which is antiseptic in its action. The results obtained with creosoted timber up to the present time do not indicate that such cracking or splitting and consequent decay, are among the serious defects of the creosoting process. It seems reasonable to conclude that a tie which has been subjected to the continued high sterilizing temperature has developed splits in those weak portions where splits would otherwise have taken place under natural conditions, and these splits or cracks, developed in the earlier steps of the process, are filled with the antiseptic and waterproof material during the later stages, thereby excluding permanently both air and water.

DRY DOCK WITH STEEL CAISSON FOUNDATIONS AT THE PORT OF TOULON, FRANCE.

(With two-page plate.)

A novel application of pneumatic steel caisson foundations has been recorded in the construction of the new dry dock of Missiessy, at the French naval port of Toulon. In 1893 it was decided by the French authorities to add a third and larger dry dock to the two which had been completed in 1881 at this port. The original project was to build a dock 180 m. (590.4 ft.) long and 35.44 m. (116.24 ft.) wide at the top, but for reasons of economy the length was reduced to 150 m. (492 ft.) before the work was ultimately begun. As the result of a general competition, a plan was adopted which provided for the founding of the dock on a single steel pneumatic caisson, and work was begun on this plan. After construction had progressed for some time, the authorities decided that a larger dock than had been planned was desirable, and they, therefore, concluded to lengthen the structure under way about 25 m. (82 ft.), and to found the addition on a caisson similar to the one adopted for the original dock. As the design was fully worked out, therefore, it provided for a dry dock 185.8 m. (609.42 ft.) long, out to out, founded on two steel caissons having the same width, but one being considerably longer than the other.

At the site selected for the new dry dock the underlying earth consisted of two dissimilar strata

of the same material, which was a pudding stone composed of pebbles of varying sizes bound together by a cementing material, which was sometimes of a sandy nature and sometimes argillaceous in character. Practically the only difference between the top and bottom layers of this material was that the cementing material became harder in the latter. The harder stratum was for the most part at a depth below the foundation bed of the caisson. The softer material through which the excavation had to be made was rather intractable, but quite permeable by water. It was, moreover, water-laden from the drainage from the inland hills just back of the port and from the harbor waters into which it extended. The problem of successfully sinking the foundations of the new dock through this material was the one which most concerned the several competitors for the work as well as the engineers.

As already stated, the type of foundation finally adopted was steel caissons sunk by compressed air. As the dock was originally planned only one caisson was to be employed, although a second was added to the first after the change in the original plans was made, as is noted above. This single caisson design was submitted by Mr. Hersent, Contractor, of Paris. Another design employing pneumatic caisssons was submitted by La Societe d'Entreprises generales de Travaux Publics, which proposed to use ten different foundation caissons, one for the entrance, eight for the walls, and one for the bottom. A third plan, which consisted simply in enclosing the foundations by a cofferdam and laying the masonry dry in the usual manner, was submitted by M. Moreau, a contractor of Marseilles. The danger of not being able to handle the seepage led the authorities to throw out the scheme for open pit construction at once. The second plan to use ten separate caissons was regarded more favorably, but it was finally laid aside as inferior to the single caisson plan principally because of the fear that the numerous lines of junction in the masonry would weaken it.

The single caisson plan finally adopted consisted first in dredging a foundation pit for the dock. While this dredging was in progress it was proposed to construct the caisson on ways or in some other position from which it could be floated to its location and sunk in the ordinary manner of caisson work. It was considered that the only doubtful feature involved in this plan arose in connection with the ballasting of the caisson so as not to endanger the structure by uneven loading. To provide against this danger very careful calculations were carried out before and during the construction, and the work was carefully conducted to conform to these calculations. Its various portions were carried out in the following order: (1) Excavation and the erection of the caisson; (2) loading and sinking the caisson; (3) execution of the foundations by compressed air; (4) lengthening the dock.

Excavations and Caisson Erection.—It was planned to erect the steel caisson in a dry pit which could afterwards be connected with the sea in such a manner that the caisson could be floated into position. The excavation work, therefore, consisted first in dredging the foundation site of the new dock to a depth of 15.9 m. (52.15 ft.) below low water, and second in excavating the erection pit for the caisson to a depth of 2.2 m. (7.216 ft.) below low water and connecting it with the sea to float the caisson. Chronologically the digging of the erection pit was the first work done. Work was begun Sept. 4, 1894, and completed June 21, 1895, during which time about 33,157 cu. m. (43,369 cu. yds.) were excavated. The excavation was done by means of carts, and the chief difficulty experienced was from seepage. This amounted to about 500 liters (130 gallons) per second, and came principally from one of the holes sunk into the pudding stone in making the test borings. This incident is chiefly interesting as showing that the engineers' objections to an open pit foundation such as was proposed by one of the competitive plans, were well founded.

The erection of the caisson in the pit was begun May 31, 1895. Timbers were first laid on the bottom of the pit, and iron plates placed on them to give a bearing to the steelwork of the caisson. This latter is quite clearly shown by plan and sections in Fig. 1. The drawing shows both the original caisson and the extension afterwards constructed. As will be seen, the construction was exactly similar in the original caisson and in the extension caisson, and consisted of a series of transverse and longitudinal girders carrying a steel plate floor and bracing together circumferential walls with cutting edges. For a distance of 13.67 m. (44.84 ft.) at the middle the transverse beams are 4.43 m. (14.53 ft.) deep, and this depth gradually increases from the middle section to depths of 6.7 m. (21.97 ft.) at the ends. Above the floor line the webs of these girders are latticed, but below the floor line they are solid and divide the working chamber into transverse apartments. The transverse beams connect at their ends with the outer walls of the caisson, and are braced together at four intermediate points by longitudinal girders 2.56 m. (8.39 ft.) deep at the middle and 4.9 m. (16.07 ft.) deep at the ends. Two of these girders are located 1.5 m. (4.92 ft.) from the longitudinal walls of the caisson, and the other two are located 12.62 m. (41.39 ft.) from the same points. Between the main longitudinal girders longitudinal roof beams 0.95 m. (3.12 ft.) deep are placed 1.5 m. (9.92 ft.) apart, c. to c. The horizontal steel plating carried by the framework just described, formed, as has probably already been surmised, the roof of the working chamber. On the same framework was supported the outside housing or cofferdam of steel plating carried by brackets and posts, as shown by the drawings. The plating of the working chamber roof was 0.5 mm. (0.2-in.) thick, that forming the webbed lower portion of the transverse girders was 0.7 mm. (0.28-in.) thick, and that forming the skin of the caisson varied from 0.5 mm. to 0.7 mm. (0.2 to 0.28-in.) in thickness.

The portion of the caisson erected in the pit before admitting the water was that comprised below a plane of 7 ft. above the cutting edge. This work necessitated the erection of 165,000 kg. (3,630,000 lbs.) of steel, and the driving of 417,000 rivets from 12 to 18 mm. (0.46 to 0.72-in.) in diameter. The cost of erection was 0.033 fr. per kilogram of metal.

The erection of the caisson was completed on Dec. 10, 1895, but the tests made to determine the tightness of the working chamber required some days longer, so that the caisson was not finally ready to float until Dec. 31, just seven months from the day that the work of erection was begun. The tests referred to consisted in clearing the pit from all debris and tools, mooring the caisson firmly, and then letting water into the pit to a depth of within a few inches of the line of flotation, which was 25 mm. (1 in.) below the roof plating. This forced the air in the working chamber to escape through the defective joints and thus reveal their location, so that the necessary calking and tightening could be accomplished after the water had been pumped out. The tightening was completed and water finally let into the pit on Dec. 21.

Meanwhile the foundation pit proper for the dock had been begun on June 21, 1895. Altogether about 196,503 cu. m. (257,025 cu. yds.) of material were dredged from the pit, the work being completed on Dec. 14, 1896. About 40,000 cu. m. (52,320 cu. yds.) of the excavated material were preserved for grading around the completed work, and the remainder was hauled to sea and dumped. Much of the dredging was very difficult; the pudding stone, especially near the bottom of the pit, being intractable.

Loading and Sinking the Caisson.—The work of loading the caisson began on Feb. 15, 1896, some months before the foundation pit was ready. The caisson was first towed from the erecting pit and then moored alongside one of the neighboring quays. The work consisted first in erecting the cofferdam, and second in placing the masonry. From Feb. 27 to Dec. 18, 1896, this work was carried on with the caisson moored at the quay, and the sinking was continuous except for a period in July when the cofferdam was being built, and another period in November and December when a delay was necessary to allow the dredges to finish the foundation pit, since the water near the quay was not deep enough for further sinking. The caisson was towed into position over the foundation pit and sinking resumed on Dec. 18, 1896.

When the caisson was floated it had a freeboard of about 5 m. (16.4 ft.), and as the work was done in calm water it was not necessary to begin to erect the cofferdam until this freeboard had decreased to about 1 m. (3.28 ft.). The erection of the cofferdam was a task of very ordinary character, and calls for no special mention, except for that portion where the entrance of the dock was to be located. As will readily be understood, this portion of the cofferdam had to be of such character that it could be removed when the work was completed. For this reason it was made in the form of a floating gate or caisson which could be bolted to the adjacent parts of the fixed cofferdam. As will be seen from Fig. 1, this floating gate was made roughly to conform to the shape of a boat. It was built on land and launched, and, after being towed into position, was set on six brackets fastened to the outside of the caisson walls about 6 m. (19.68 ft.) above the cutting edge. The connections were made with bolts, the joints being covered with a mastic to prevent leakage.

In placing the masonry the first thing done was to cover the entire floor plating with a layer of cement mortar 2 cm. (0.8-in.) thick. This covering served the double purpose of making the platform air-tight and of furnishing a binder for the concrete bottom masonry. This concrete bottom was 0.93 m. (3.05 ft.) thick, laid in three layers each 0.31 m. (1.0168 ft.) thick. The two bottom layers were entirely of cement concrete, but of the top layer only that portion lying 1 m. (3.28 ft.) on each side of the main transverse and longitudinal girders was cement concrete, the interior portions being lime concrete. These three layers of concrete brought the level of the top of the masonry 0.95 m. (3.116 ft.) above the top of the roof plating, or to the tops of the small roof beams. One of the principal objects of this concrete bed course was to give stiffness to the caisson, which had very little rigidity by itself.

The regular floor and wall masonry began immediately on top of the bed course just described. First the position of each main girder extending above the bed course was embedded in a ridge of masonry 1.5 m. (4.92 ft.) thick and 2 m. (6.56 ft.) wide, laid in cement mortar, and a mass of the same dimensions was bedded against each side wall. The compartments between these cement mortar walls were filled level with masonry laid in hydraulic lime mortar. In laying this masonry and the masonry that followed great caution had to be employed in distributing the load to secure equal settlement and to prevent distortion of the caisson. The plan and sections in Fig. 2 show the completed masonry in all of its important details.

As previously stated, the depth to which the foundation pit was dredged was the depth at which the cutting edges of the caisson were to remain permanently. During and after the dredging, however, a sediment of fluid clay settled on the bottom of the pit about 1 m. (3.28 ft.) thick, through which the caisson had to be sunk. Some trouble was had in doing this work, since the clay deposit ocmpacted itself under the cutting edges so tight that the water in the working chamber could not escape, and, therefore, the settlement of the caisson ceased at a height of 0.12 m. (0.393 ft.) above the required depth. This difficulty was overcome by having a diver bore holes in the side walls of the working chamber to permit the water to escape. After these holes were bored the work progressed smoothly.

Compressed Air Work.—After the caisson had reached its final depth the working chamber was emptied of water by forcing in air. The first work was to get rid of the layer of soft clay previously mentioned, and this was done by diluting the clay and siphoning it off by means of the air pressure. This work required about seven or eight days for each compartment of the working chamber, with a working force of from eight to ten men. The cost for compressed air for each compartment was about 500 francs ($100). It was found that the dredges had left the foundation bed quite smooth and even.

The placing of the concrete, which was begun as soon as the chambers had been made dry, required about 3,500 working hours for each compartment,

1.8 to 1.95 m. in dimensions. The cost of compressed air for each compartment was 750 francs. The concrete was introduced into each [illegible] by means of two shafts located 9.98 [illegible] from the exterior walls of the caissons. Where their outlets were obstructed by the [illegible] which proceeded from the edges toward the center. Iron from the central shaft for the workmen was employed for material also. In laying the concrete the first work was to place a layer 20 cm. thick over the entire bottom. A banking of concrete was then placed around the interior [illegible] edge of the caisson, after which the filling was proceeded continuously from the outer edges toward the center.

Lengthening the Dock.—The decision to lengthen the dock was made in March, 1896, and work commenced in August, 1896. It consisted in sinking a second caisson close to the inshore end of the first caisson, as shown by Fig. 1. The joint between the two caissons was closed by means of covers constructed as shown by Fig. 3. The method adopted in sinking the small caisson was in all respects similar to that employed in sinking the large one, and, therefore, calls for no special description. The joint between the two caisson foundations was made with concrete, after which the adjacent walls were removed and the chamber masonry was built. The work of making the joint between the two caissons was carried out successfully, but it was quite troublesome.

According to an article by Mr. Guiffart in "Annales des Ponts et Chaussees," for the third quarter of 1899, the new dock has proved to be a very successful structure in all particulars. We have abstracted the preceding description of the work from this article. The total cost of the dock was 5,322,983 francs, or about $1,064,532.

THE STEAMSHIP "SIERRA," the first of three of like dimensions being built for the Oceanic Steamship Co., was launched on May 29 from the Cramps shipyard in Philadelphia. The "Sierra" is 400 ft. long, 50 ft. beam, 43.6 ft. deep; displacement, 7,000 tons; speed, 17 knots. These steamers are to ply between San Francisco, Hawaii and Australia.

THE RUSSIAN CRUISER "VARIAG," built by the Cramps, of Philadelphia, has had her builders' trial trip, and the test has been pronounced satisfactory. The trial was made about 20 miles off the Delaware Capes, and the cruiser is said to have developed 22 knots under natural draft with one boiler out of use. The contract calls for 23 knots, but the builders say she can make 24 under forced draft. The "Variag" has the largest installation of Niclausse water-tube boilers in the world; as there are 30 of them with 9,240 tubes, giving a heating surface of 55,000 sq. ft. She has twelve 6-in. guns and four of 75mm. caliber; all of these were satisfactorily tested. The official trial will take place in July.

A FIRE TEST OF A FLOOR, composed of wooden joists filled between with concrete, is reported by the British Fire Prevention Committee. The floor joists were of fir, 2 × 7 ins., spaced 12½ ins. apart, and the concrete filling between them was 5 ins. thick. This concrete was composed of five parts gas coke breeze and one part Portland cement. The ceiling attached to the bottoms of the joists was ⅝-in. tongued and grooved boards. On top there was a ⅞-in. yellow pine flooring loaded to 100 lbs. per sq. ft. The test consisted of a fire below the floor rising from 500° F. to 2,300° F. in 1¼ hours and then quenched by a stream of water. Under this test the ceiling was consumed in 15 mins.; in 60 mins. the floor had sagged, cracking the concrete transversely to the joists; in 74 mins. the concrete between two of the joists fell, and in 82 mins. the whole floor collapsed. The joists were found broken in the center, with their bottoms charred to a depth of from 2 to 2½ ins. The floor boards were but slightly burned.

ANOTHER 24-IN. GAS MAIN is being laid under the Harlem River by the Consolidated Gas Co. It is intended to furnish an additional supply of gas to the Borough of the Bronx. The pipe will be laid about 50 ft. north of the Madison Ave. bridge, in a trench dredged for it. A flexible joint will be used in the 75 lengths of 12 ft. each that will be required.

POWERFUL GAS-ENGINES are described in "Stahl und Eisen," of March 15, 1900. Mr. Muenzel gives a complete historical account of the development of this type of motor, and among other plants in use he describes the central station of Horde. There are here two groups of gas-motors of 600 HP. each; each group includes two gas-engines coupled directly to an alternator. In the central station at Friedenhutte, at Morgenroth, furnace gas is utilized to produce power and electric light; and there are six motors of 300 HP. coupled directly to alternators, and two motors of 300 HP. coupled directly to a dynamo. A gas generator, sufficiently large to produce a force of 2,000 HP., has been installed nearby in case the supply from the furnaces should be insufficient. The central station at Bale, Switzerland, has three motors, of 300 HP. each, fed by gas from a coke-furnace; the output of power is said to be equal to 0.93 kilowatt for one kilogram of coke.

THE MT. PROSPECT LABORATORY OF THE BROOKLYN WATER-WORKS, GREATER NEW YORK *

By George C. Whipple, Assoc. M. Am. Soc. C. E., Biologist and Director.

The practical value of the sciences in our modern civilization is strikingly attested by the increase in the number of laboratories connected with various departments of nation, state and municipality. This is emphatically true in the domain of sanitary science, where the advances in chemistry, microscopy and bacteriology have wrought revolutionary changes. With the knowledge that many diseases are caused by living organisms, and that some of them are transmitted by water, came the need of more careful supervision of public water supplies, which resulted in the establishment of laboratories devoted to water analysis. The pioneer work of the Massachusetts State Board of Health has been followed by the installation of laboratories in most of our large American cities. In many instances these are operated in connection with the departments of health, but in Boston, Lynn, Louisville, Cincinnati, Pittsburg, Albany, Washington and elsewhere laboratories have been organized in connection with the departments of water supply, either for the purpose of experimental work or because the character of the water supply was such that proper management depended upon analytical as well as engineering data. Departments of water supply should be justly held responsible for the quality as well as the quantity of the water supplied to the public. This involves a constant knowledge of the sanitary condition of the water, which can be obtained only by frequent analysis and inspection.

FIG. 1.—EXTERIOR VIEW OF MOUNT PROSPECT LABORATORY, BROOKLYN WATER-WORKS.

The complicated character of the water supply of Brooklyn made the need of a laboratory apparent to the Department of Water Supply several years ago, but it was not until 1897 that an appropriation for the purpose was obtained. In May of that year the writer was appointed biologist and director of the laboratory, and instructed by Mr. I. M. De Varona, Engineer of Water Supply, to prepare plans for the installation and equipment of a complete chemical and biological laboratory. Mt. Prospect reservoir, near the entrance to Prospect Park, was selected as the most available site, and the gate house of the reservoir was found to have ample accommodations. Contracts were let during the summer, and the laboratory was in complete operation on the 1st of October, though regular microscopical examinations of the water were begun early in July. (Exterior and interior views of the laboratory are shown by Figs. 1 and 3, respectively, while Fig. 2 shows the main floor plan.—Ed.)

Mt. Prospect laboratory has a fortunate location. It is conveniently near the Long Island depot, where the samples from the watershed are received, Ridgewood reservoir, the main distribution reservoir, and the office of the department at the municipal building. Its isolation and elevation make it comparatively free from noise and dust, while the building is well lighted by large windows, heated by hot water, provided with gas, electricity and telephone. The upper portion of the building contains three rooms, besides the keeper's office, and a corridor from which visitors may ascend to an observatory on the roof. The three rooms are known as the general laboratory, or preparation room, the biological laboratory, and the chemical laboratory. In the basement are the physical laboratory, the general store room and the furnace room. There is also a sub-basement, suitable for bacteriological work during hot weather.

The general laboratory is devoted to the shipment of bottles and reception of samples, the washing of glassware, the sterilization of apparatus, the preparation of culture media and to such chemical operations as might charge the air with ammonia and the fumes of strong acids. The room contains a well-ventilated hood; a work table, under which are closets and drawers; a shipping desk; a large sink, with draining boards on the sides; a drying oven; a hot-air sterilizer; a steam sterilizer; an autoclav; an automatic still, and a distilled water tank, lined with block tin and having delivery tubes that extend to the other rooms.

The biological laboratory is devoted to the bacteriological and microscopical examinations of water and to the study of the various organisms found. It also forms the office of the director. It contains a work table; a long work shelf, with three windows in front; three incubators; an ice chest for the storage of culture media; a case for sterilized apparatus; a bookcase, with a good working library; a desk; a typewriter, and cabinets for report blanks, biological specimens, etc. Electric bells connect with the different laboratories and with the telephone in the office of the keeper of the reservoir.

The chemical laboratory is the largest of the three rooms. Its atmosphere is kept free from ammonia and from the fumes of strong acids, in order not to vitiate the results of the water analyses there carried on. It contains a table for holding the samples of water that are being analyzed; three work tables; two work shelves, with windows in front; a weighing room, with balance in front of window and with a wide desiccator shelf and a drying closet; a hood, under which are two steam baths; a battery of twelve stills for ammonia distillations; a still for obtaining redistilled water; an apparatus for gas analysis; a battery of twelve Sedgwick-Rafter filters, used in the microscopical examination of water; an apparatus case; a case for chemicals; a Richards pump, and various pieces of specially designed apparatus that facilitate the work of analysis. The room also contains a combustion furnace and a Mahler bomb calorimeter for the analysis of coal and the determination of its heating power. A storage room opens from the chemical laboratory, and there is a small dark room under the stairs. The three laboratories have marble-tiled floors, and the work tables and shelves are covered with white tiles throughout. The partitions between the rooms are largely of glass.

The physical laboratory in the basement is not fully completed. At present it contains a crusher, a coal sampler, sieves for sand analysis, and a cement-testing machine, with its accessories. Much of the room is devoted to storage and to shop work.

The laboratory force consists of one biologist and director, one chemist, one assistant chemist and three assistants.

The work of the laboratory may be divided into three parts—water analyses, miscellaneous analyses and experimental work.

*A paper read before the Brooklyn Engineers' Club, April 12, 1900.

Water Analyses.

The routine work consists of the regular examination of samples of water received from all parts of the watershed and distribution system, i. e., from the driven wells, streams, ponds, aqueducts, reservoirs and service taps. The complicated and varied character of the water supply requires the examination of an unusually large number of samples, and it is safe to say that no water supply in this country is examined more thoroughly and minutely than that of Brooklyn. The regular routine includes the bacteriological examination of three samples of water from the Ridgewood pumping stations and from a tap in the city collected daily; the complete physical, chemical and biological examination of nine samples from the distribution system collected weekly; the physical, biological and partial chemical examination of 24 samples from the supply ponds collected weekly, with complete chemical analyses monthly; the complete examination of 19 samples from driven wells collected monthly; and the complete examination of 21 samples from the private water supply companies of Brooklyn and from the water supplies of the Borough of Queens, collected quarterly. In addition to these regular samples many extra samples are taken at various times and places, as occasion requires. During the 2½ years that the laboratory has been in operation this schedule has resulted in the analysis of more than 6,000 samples, as follows:

Samples received from July 12, 1897, to April 1, 1900.	6,471
Physical examinations	5,025
Complete chemical analyses	2,562
Partial chemical analyses	1,049
Microscopical examinations	4,688
Bacteriological examinations	5,230
Tests for bacillus coli communis	2,630

The samples of water from the watershed are collected in the forenoon during the early part of each week and sent to the laboratory by express. The average time that elapses between the collection of a sample and the beginning of its analysis is about four hours, but this time varies from ten minutes to eight hours. Samples are collected in large bottles for chemical analysis and in small sterilized bottles for bacteriological examination. The large bottles have a capacity of one gallon, are made of heavy, clear, white glass, and have glass "hood" stoppers. They are not sterilized, but are carefully cleaned with chromic acid before leaving the laboratory. Brown paper is tied over the stoppers to prevent contamination from dust, and the bottles are packed in boxes that have separate compartments lined with indented fiber paper and that are provided with tight-fitting covers. The breakage of bottles packed in this way is very small.

The bottles for the bacteria samples hold 2 ozs., and are made of clear, white glass, and have wide mouths with glass stoppers. They are known to the trade as "chemical salt mouths." These bottles are sterilized each time before use. The stoppers of the bottles are covered with pieces of tin foil, and each bottle is then placed in a screw-capped tin box, just large enough to receive it. The tin boxes are painted to keep them from rusting. The bacteria samples are shipped in portable ice-boxes. There is an outer box with asbestos packing and a copper lining and an inner copper tray, divided into compartments to hold the tin boxes just mentioned, and between the outer box and the tray is a large space for ice. The box holds sufficient ice to last eight hours in hot weather, and the samples almost invariably are received in good condition.

The samples from the supply ponds are collected at a depth of 1 ft. below the surface. The shallowness of the ponds makes it unnecessary to collect samples at greater depths. The samples from the distribution reservoirs are collected just outside the gate houses, where the flowing water gives a representative mixture of the water entering or leaving the reservoirs. Special precautions are taken to avoid contamination in the collection of samples, and to this end special forms of collecting apparatus have been devised.

In the apparatus for collecting the bacteria samples the sterilized bottle is placed in a metal frame attached to the lower end of a small brass tube, and is held in position by spring clips. A small rod extends through the brass tube, and at the lower end is provided with a clutch for grasping the stopper of the bottle. By means of this rod the bottle may be opened and closed under water.

The apparatus used for collecting samples from beneath the surface, when necessary, is as follows: The frame consists of a brass wire attached to a weight with clips for holding the bottle. The frame is supported by a spring joined to a sinking rope. A flexible cord extends from the top of the spring to the stopper of the bottle. The length of this cord and the length and stiffness of the spring are so adjusted that when the apparatus is suspended in the water by the sinking rope the cord will be just a little slack. In this condition it is lowered to the desired depth. A sudden jerk given to the rope stretches the spring and produces sufficient tension on the cord to pull out the stopper.

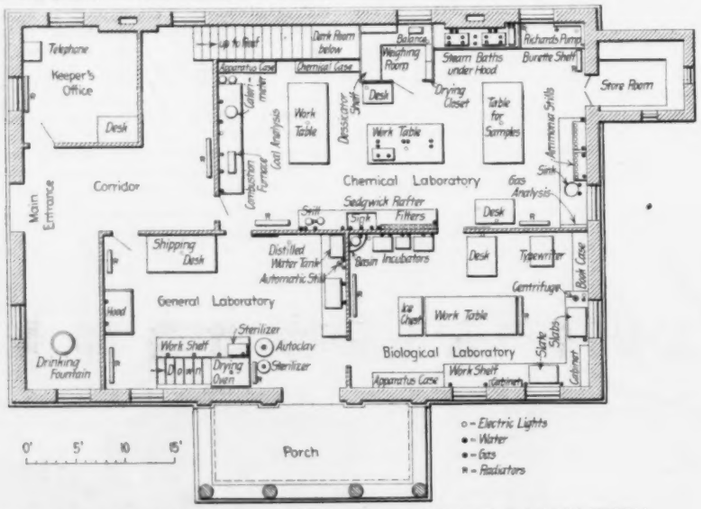


FIG. 2.—PLAN OF MAIN FLOOR, MOUNT PROSPECT LABORATORY.

The apparatus for collecting bacteria samples from beneath the surface is similar in principle. The bottle is replaced by a sterilized vacuum tube, with end turned outwards and backwards and drawn to a point. The pull of the cord breaks off the tip of the tube and the pressure of the water causes the tube to fill. The end may be then sealed with an alcohol lamp or closed with a bit of sterilized wax. The frame for holding the tube consists of a short piece of lead pipe, which also serves as a weight.

The temperature of each sample is taken at the time of collection and recorded on a certificate, together with the locality of the sample, the date of collection, the name of the collector, etc. Temperature reading below the surface are obtained with the thermophone.*

When the samples reach the laboratory each is given a serial number and entered in an index book, and throughout all the examinations each sample is known by its number rather than by the name of the locality from which it was collected.

It would be out of place in this paper to describe in detail all the methods used in the analysis of the samples, but inasmuch as methods differ considerably in different laboratories, it seems desirable to give at least an outline of the methods used and to describe such as differ materially from those practiced elsewhere.

Physical Examination.

The physical examination includes the observation of the temperature of the water, its general appearance, its turbidity, its color and its odor.

Temperature.—The temperature of the sample is observed at the time of collection, as mentioned above.

Appearance.—The amount of sediment and the turbidity, after standing twelve hours, are estimated by inspection and recorded numerically according to the following scale: 0, none; 1, very slight; 2, slight; 3, distinct; 4, decided.

Turbidity.—The actual turbidity is determined by comparison of the sample with silica standards of turbidity, as described by Whipple and Jackson in the "Technology Quarterly" for December, 1899. According to this standard, a turbidity of 100 is equal to that produced by adding 100 mg. of finely divided diatomaceous earth to one liter of water. Comparisons are made in gallon bottles or in Nessler jars, held toward the light or placed over a series of black lines.

Color.—The color is determined by comparison with the platinum-cobalt standard, described by Hazen in the "American Chemical Journal," Vol. XIV, p. . The comparisons are made in 100 cu. cm. Nessler jars, 5 ins. in diameter and 12 ins. long.

Odor.—The "cold odor" is observed after vigorously shaking the bottle in which the sample is contained. The "hot odor" is observed by heating about 200 c.c. of the sample in a beaker, covered with a watch glass, to a point just short of boiling and applying the nose as soon as the water has sufficiently cooled. The results are expressed according to the following scale of intensity and with the following abbreviations:

Scale of Intensity.—0, none; 1, very faint; 2, faint; 3, distinct; 4, decided.

Abbreviations.—v, vegetable; e, earthy; a, aromatic; g, grassy; f, fishy; m, moldy, etc.

Chemical Analysis.

The sanitary chemical analysis ordinarily includes the determination of the nitrogen as albuminoid ammonia, free ammonia, nitrites and nitrates; total residue on evaporation, loss on ignition, chlorine, iron and hardness. In addition to these, the following determinations are sometimes made: Oxygen consumed, alkalinity, incrusting constituents, dissolved oxygen, carbonic acid, etc.

Form of Expression.—The results of the chemical analysis are expressed in parts per million.

Nitrogen as Albuminoid Ammonia.—The method of Wanklyn is used, according to the practice of the Massachusetts State Board of Health, described in the two special reports on water supply and sewerage published in 1890. The total albuminoid ammonia is determined on the unfiltered water. The dissolved albuminoid ammonia is determined after filtering the sample through filter paper. The suspended albuminoid ammonia is found by subtracting the dissolved albuminoid ammonia from the total albuminoid ammonia. In the case of ground waters only the total albuminoid ammonia is determined. The form of distilling apparatus is practically the same as that designed by Mr. H. W. Clark and used at the laboratory of the Massachusetts State Board of Health.

Nitrogen as Free Ammonia.—The free ammonia is determined by Wanklyn's method, referred to under albuminoid ammonia. Five hundred cu. cm. of the sample serves for the determination of both the free and albuminoid ammonia.

Nitrogen as Nitrites.—Warrington's modification of the Griess method is used.

Nitrogen as Nitrates.—The phenolsulphonic acid method of Grandval and Lajoux is used, but with certain modifications tending to refinement. The quantities of water operated upon vary from 2 to 50 cu. cm., according to the amount of nitrogen present as nitrates. Permanent standards are used instead of preparing fresh standards for every set of comparisons. Comparisons are made in 100 cu. cm. Nessler jars.

Residue on Evaporation.—For the determination of the residue on evaporation 200 cu. cm. of the sample are evaporated to dryness on a water bath in a platinum dish of known weight, dried for half an hour in a steam oven, cooled in a desiccator and weighed. Where it is necessary to determine the amount of suspended matter the residue is determined both before and after filtering the sample through filter paper or through a Pasteur filter, and the difference obtained.

Loss on Ignition.—After the determination of the total residue on evaporation the platinum dish is placed in a larger platinum dish that serves as a radiator, ignited for seven minutes at a low red heat, treated with a small amount of distilled water to restore any loss of water of crystallization that may have been driven off by the ignition, evaporated to dryness on the water bath and dried, cooled and weighed as before. The difference of weight before and after ignition gives the loss on ignition. The loss on ignition is not determined for the ground waters or for the water of the distribution system, which is a mixture of the surface and ground waters.

Chlorine.—The chlorine is determined by titration with silver nitrate, using potassium chromate as an indicator, according to Hazen's modification of Mohr's method, described in the "American Chemical Journal," Vol. XI, p. 409.

Hardness.—The hardness is determined by Clark's soap method, substantially as described in Sutton's "Volumetric Analysis," but with certain modifications in the preparation of the soap solution. No attempt is made to separate the "temporary hardness" from the "permanent hardness" by the method of boiling. The information covered by these terms is obtained when required by the determination of the alkalinity and the incrusting constituents.

Alkalinity.—The alkalinity of a water is a measure of the carbonates and bicarbonates present. It is ordinarily determined by titrating 100 cu. cm. of the sample with N/50 H_2SO_4, using methyl orange as an indicator; but it is sometimes desirable to substitute lacmoid for methyl orange as an indicator, making the titration after heating the sample to the boiling point. It has been found that when the true end-points are known and the proper corrections for the indicators are applied methyl orange and

*Henry E Warren and Geo. C Whipple, "The Thermophone," "Technology Quarterly," July, 1895.

...practically the same results. These indicators differ in their power of showing the presence of sulphuric acid, and methyl orange should not be used in determining the alkalinity of a water that has been treated with coagulant.

...Constituents.—The incrusting constituents are those that give to water its "permanent hardness." The determination is made according to Hehner's method, described by Leffman in his "Examination of Water." The sum of the alkalinity and incrusting constituents is considered equal to the hardness as determined by the soap test.

...Iron is determined from the residue in the platinum dish according to Thompson's method, as described in Mason's "Volumetric Analysis," but with certain modifications in technique that tend to greater accuracy.

Oxygen Consumed.—The Kubel method is used substantially as described in the special reports of the Massachusetts State Board of Health, above referred to. The period of boiling is five minutes. This determination is seldom made on the regular samples.

Dissolved Oxygen.—Winkler's method is used according to the modifications of Drown and Hazen, described in the special reports of the Massachusetts State Board of Health, above referred to.

Carbonic Acid.—Pettenkofer's method is used according to the modifications of Trillich, described in Ohlmuller's "Untersuchung des Wassers," edition of 1896.

Microscopical Examination.

The microscopical examination of water determines the number and kind of microscopic organisms present, together with the amount of amorphous matter. The Sedgwick-Rafter method is used, with the modifications described in the author's "Microscopy of Drinking Water." The results are expressed in number of standard units of organisms per cubic centimeter.

Bacteriological Examination.

The bacteriological examination consists of the determination of the number of bacteria present in a sample of water and a qualitative test for the presence of bacillus coli communis. No general qualitative work is undertaken in connection with the regular routine.

Quantitative Examination.—One cubic centimeter of the sample (diluted 1-10, or 1-100, if necessary) is mixed with 5 cu. cm. of sterilized nutrient gelatine in a petri dish and allowed to cool on a level surface. When hard the culture is placed in an incubator and kept at a temperature of 20° C. in an atmosphere saturated with moisture for 48 hours, after which the number of developed colonies is counted. It is then returned to the incubator and kept 24 hours longer, after which a second count is made. The 72-hour count is the one reported. All determinations are made in duplicate. The gelatine used as the culture medium is prepared substantially as recommended in the report of the Bacteriological Committee of the American Public Health Association, published in 1898. It is given an acidity of 1.5%.

Test for Bacillus Coli Communis.—Smith's fermentation method is used as the basis of the test, isolation of the colon bacillus according to ordinary qualitative methods being attempted only when a positive test is obtained in the fermentation tube. If the amount of gas in the fermentation tube after 48 hours' incubation at 37° C. is above 30% and below 70% of the closed arm, a portion of the sediment is plated on lactose-litmus-agar. If red colonies develop after 12 hours' incubation transfers are made from them to glucose-gelatine, milk, nitrate solution, sugar-free broth (for indol), and glucose broth in a fermentation tube. If these tests give positive results, the presence of the colon bacillus is considered as proven.

It is not within the province of this paper to discuss the quality of the water supply of Brooklyn—that belongs more properly to the annual reports of the Department of Water Supply—but an account of the growths of microscopic organisms in the supply may be of general scientific interest.

Microscopic Organisms in the Brooklyn Water Supply.

The troubles of the Brooklyn water supply during the past few years have been occasioned by the growth of odor-producing organisms in the distribution reservoirs. The growth of Asterionella in Ridgewood and Mt. Prospect reservoirs and its effect upon the quality of the water have been so fully described (report of Dr. Albert R. Leeds to the Department of City Works, division of water supply, Brooklyn, 1897) that it is not necessary to again relate the details of its occurrence. That the growths of Asterionella continue to occur periodically is shown by the profiles on Fig. 4.

Asterionella is not the only odor-producing organism that develops in the distribution reservoirs. Anabaena, Synedra, Cyclotella and other forms are sometimes present in great abundance. The character of the water collected from the watershed of the Brooklyn supply is such as to furnish abundant nourishment for microscopic plant life, and organisms that in many water supplies appear in small numbers without having any noticeable effect on the character of the water develop in Brooklyn to an enormous extent.

This is emphatically true in the case of Synedra pulchella, a diatom that until recently has not been classed as an odor-producing organism. Like Asterionella, this diatom contains oil-globules, but the oily substance has not the same strong odor as the oil of Asterionella. Nevertheless, Synedra is capable of imparting an odor to water if present in sufficient numbers. The odor is not a characteristic one like that of Asterionella, Uroglena, Dinobryon, etc., and can be described by no more exact term than "vegetable." The taste imparted to water by Synedra is perhaps more noticeable than the odor, being somewhat "earthy," as well as "vegetable."

In few water supplies in this country is Synedra pulchella ever present in numbers greater than 5,000 per cu. cm. and, although a smaller number than this will make a water turbid, it requires about this number to produce a noticeable odor. In Brooklyn, however, the growths of Synedra have been much heavier, as may be seen from Fig. 4. On several occasions the numbers have reached 15,000 per cu. cm., and once as many as 20,000 per cu. cm. were observed. The water at such times has been very turbid, and has had the vegetable and earthy taste and odor just referred to.

The seasonable distribution of Synedra in the Brooklyn reservoirs is worth noting. In Mt. Prospect reservoir it has appeared regularly in the spring and fall, according to the usual mode of occurrence of the diatoms, but it has always appeared after the Asterionella growths in the spring and before the Asterionella growths in the fall. In Ridgewood its occurrence has been more variable. In 1899 there were heavy growths in basins 1 and 3 during the month of August.

Cyclotella is another diatom that, because of its limited occurrence, has been seldom known to cause trouble in water supplies. Yet in Ridgewood reservoir it is sometimes present in large numbers. Its growth has been usually of short duration, but when present in numbers equal to 5,000 standard units per cu. cm. its aromatic odor could be distinctly recognized.

wind. The water was entirely unfit for use, and the gates of the reservoir were kept closed. As soon as the organisms disappeared in the fall and the [illegible] had again assumed its normal condition, Basin 2 was emptied and cleaned, with the hope of preventing recurrence of such growths in the future. An examination of the deposit at the bottom of the reservoir showed that it was well seeded with the spores of Anabaena. Since that time there has been no further development of this organism.

In September, 1898, a phenomenally large growth of Scenedesmus occurred in Mt. Prospect reservoir, the water at one time containing 25,800 standard units per cu. cm. This organism, in the numbers ordinarily found, causes no odor, but on this occasion the water had a distinct vegetable and aromatic odor and taste. The growth continued for several weeks.

There are several other organisms that deserve mention, because they occur in larger numbers in the Brooklyn water than in most water supplies. Dictyosphaerium, Eudorina, Mandorina and Volvox are often present in numbers of 500 standard units per cu. cm. Clathrocystis is not often found in Ridgewood reservoir, but in Mt. Prospect reservoir it has been as high as 1,440 standard units per cu. cm. As a rule the Brooklyn water contains comparatively few protozoa, but Mallomonas has been observed as high as 660 per cu. cm. in Ridgewood reservoir, and Cryptomonas has been as high as 2,000 per cu. cm. in Mt. Prospect reservoir. Chlamydomonas has been found occasionally.

To the water consumers of Brooklyn, however, the important fact is not the number of organisms in the distribution reservoirs, but the number present in the tap water in the city. Prior to the construction of the by-pass at Ridgewood the organisms that developed in the reservoir found their way as a matter of course to the service taps of the consumers. But by using the by-pass it has been found possible to so regulate the distribution

FIG. 3.—VIEW OF A PORTION OF THE CHEMICAL LABORATORY.

Two species of Melosira occur in the Brooklyn supply. Melosira granulata, the common free-floating form, is seldom present in sufficient numbers to cause trouble, though 2,000 or 3,000 per cu. cm. are sometimes found. Melosira varians grows luxuriantly on the shores of Ridgewood reservoir, and constant scraping is required during the summer to keep the banks clean. During severe storms the filaments of Melosira become detached from the shores and are scattered through the water, and on one occasion the amount of vegetable matter so detached was sufficient to impart a distinct taste to the water. Like Synedra pulchella, Melosira produces simply a vegetable, earthy and somewhat oily taste and odor, very different from the aromatic-fishy odor of Asterionella and Cyclotella.

Next to Asterionella, Anabaena has probably caused more trouble in the Brooklyn water supply than any other organism. During the past two years it has appeared but once, but there are good reasons to believe that in the summer of 1896, prior to the investigations of Dr. Leeds, the disagreeable odor of the tap water was due not so much to Asterionella as to Anabaena.

In July, 1898, anabaena appeared in all the Ridgewood basins. In Basin 3 it did not develop to any extent. In Basin 1 it attained a maximum growth of 1,720 standard units per cu. cm. on Aug. 19, and gave to the water its characteristic odor of moldy grass. In Basin 2, however, it developed to an enormous extent. On Aug. 3 there were 24,000 standard units per cu. cm. From the last of July until early in September the water in the basin was densely turbid and had a green color. On quiet days a scum collected on the surface and drifted about with the

of the water that very few organisms reach the consumers. Guided by the frequent and regular microscopical examinations made at Mt. Prospect laboratory, the engineer has directed one or more basins to be isolated whenever it was found that odor-producing organisms were developing in them, the water meanwhile being delivered through the by-pass direct from the force mains to the distribution pipes. It has been found possible also to isolate Mt. Prospect reservoir and pump directly into the pipes when growths of organisms made it seem advisable. The beneficial effect of this management can be illustrated by the following comparison.

At the time when Dr. Leeds made his report on the condition of the water, i. e., from November, 1896, to February, 1897, Asterionella was present in the distribution system as follows:

	No. per cu. cm.
Ridgewood reservoir, Basin 1	3 to 48
" " " 2	2 " 10
" " " 3	2,608 " 4,648
Mt. Prospect reservoir	4,808 " 8,640
Tap supplied from Ridgewood, Basins 1 & 2	3 " 81
" " " " Basin 3	1,240 " 8,800
" " " Mt Prospect reservoir	2,400 " 7,460

During November and December, 1899, the corresponding figures were as follows:

	No. per cu. cm.
Ridgewood reservoir, Basin 1	5,600 to 27,280
" " " 2	0 " 8
" " " 3	0 " 16
Mt Prospect reservoir	6,512 " 24,960
Tap ordinarily supplied from Ridgewood, Basins 1 and 2	0
Taps supplied from Ridgewood, Basin 3	0 " 16
Tap ordinarily supplied from Mt. Prospect reservoir	8 " 56

During November, 1896, and February, 1897, the water supplied to the city from Basin 3 and from Mt. Prospect reservoir had a very disagreeable taste and odor, due to the presence of Asterionella, but during November-December, 1899, the water in the city had no odor due to Asterionella, even though that organism was far more abundant in Ridgewood and Mt. Prospect reservoirs than it had been during the winter of 1896-97. This freedom of the tap water from Asterionella was due to the use of the by-pass, the sections of the city that are ordinarily supplied from Ridgewood Basins 1 and 2 and from Mt. Prospect reservoir being supplied with water direct from the Ridgewood force mains.

Miscellaneous Work.

The miscellaneous work of the laboratory includes analyses of coal, lubricating oil, boiler scales, boiler compounds, cements, deposits from driven wells, etc. These

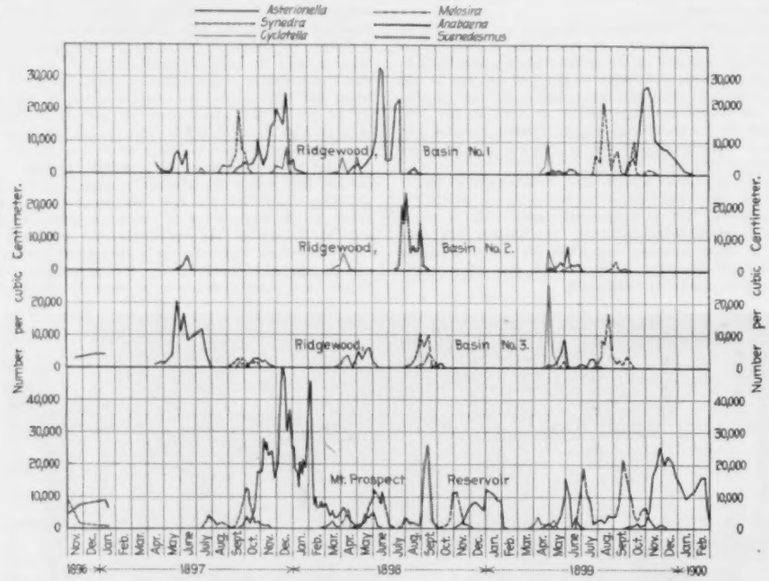


FIG. 4.—VARIATIONS IN NUMBERS OF MICROSCOPIC ORGANISMS IN THE BROOKLYN RESERVOIRS, NOVEMBER, 1897, TO FEBRUARY, 1900.

are all problems of engineering chemistry, and need not be described at length. The most important part of this work is the analysis of coal, and a brief description of the methods used may be of interest to some of the members of the club.

The specifications under which coal is purchased by the department require that each bid shall be accompanied by a sample of the coal offered, and provide that no bid shall be accepted unless the sample contains a certain number of heat units. Bituminous coals must contain not less than 13,500 B. T. U. per lb., and anthracite coals not less than 12,500 B. T. U. per lb., the calculations to be made in both cases on dry coal by the method of ultimate analysis. The amount of sulphur must not exceed 1%. The specifications also provide that

> if at any time the quality of the coal should prove inferior in any respect to that stipulated in the bid * * * or if on analysis the quality is found to be of a lower standard than that of the sample furnished with the bid, the Commissioner shall deduct such sum or sums from the estimated amount of money which would otherwise be due to the contractor, or he may deem to fairly represent the loss caused to the party of the first part by reason of the said depreciation in quality, and that in case of failure to comply with any of the other terms of this contract after due notice shall have been given to the contractor of such failure the Commissioner shall have the right to cancel the contract.

The samples of coal that accompany bids are analyzed by the method of ultimate analysis, and are also tested in the Mahler bomb calorimeter; but in the case of samples taken from each consignment the ash is determined in the combustion furnace and the heating power in the calorimeter.

The method of ultimate analysis was described by Mr. D. D. Jackson, Chemist of the laboratory, at one of the library talks of the Brooklyn Engineers' Club in 1898. The sample of coal—usually about 10 lbs.—is reduced by successive divisions to a small representative sample, which is powdered to such a degree of fineness that it will pass a sieve that has 60 meshes to the inch. The moisture is determined by ascertaining the loss in weight when dried for one hour at 110° C. This determination is made not for the purpose of obtaining the moisture in the coal as used, but in order that the results of the analysis may be calculated on the basis of dry coal. The amounts of carbon, hydrogen and ash are determined in a combustion furnace in the usual manner. The nitrogen is sometimes determined by the Kjeldahl method, but the determination is omitted on the regular work. The sulphur is determined by Eschka's method. The volatile sulphur, when required, is determined from the water left in the bomb of the calorimeter after the combustion. The oxygen is determined by difference. All of the determinations of the ultimate analysis are made in duplicate.

The heating power is calculated from the ultimate analysis according to the following formula:

$$\text{Number of B. T. U. per lb. of coal} = 14{,}544\ C + 62{,}032\left(H - \frac{O+N}{8}\right) + 4{,}500\ S,$$

where C, H, O, N and S represent the percentages of carbon, hydrogen, oxygen, nitrogen and sulphur.

Expressed in terms of calories, this formula becomes:

$$H = 8{,}080\ C + 34{,}462\left(H - \frac{O+N}{8}\right) + 2{,}500\ S.$$

The heating power of the coal is determined directly by combustion in the Mahler bomb calorimeter. A good description of this apparatus may be found in Gill's "Gas and Fuel Analysis for Engineers." About one gram of the powdered coal is weighed out in a shallow platinum pan and placed in the steel bomb of the calorimeter, after which oxygen is admitted until the pressure in the bomb reaches 25 atmospheres. The bomb is then immersed in the water cylinder and the charge ignited by means of an electric current, which is passed through a fine iron wire embedded in the coal. The heat produced by the combustion of the coal causes an increase in the temperature of the surrounding water, and from the observed rise in temperature the heating power of the coal is calculated.

An examination of the results of about 50 analyses made by the method of ultimate analysis shows that duplicate samples usually differ by about 1%, or approximately 150 B. T. U., while with the calorimeter duplicates usually agree within 50 B. T. U. Comparisons of determinations of heating power made by direct determination and by calculation from the ultimate analysis show an average difference of about 200 B. T. U.

Experimental Work.

Most of the experimental work that has been carried on in the laboratory has been in connection with problems pertaining to the condition of the water supply; but, in addition to this, considerable attention has been given to the study of methods of water analysis and to other subjects of scientific interest. For the most part these investigations have been of more interest to chemists and biologists than to engineers, but an account of the preparation of a map of the normal chlorine of Long Island may be appropriately presented to this club.*

It is well known that the amount of chlorine that a sample of water contains is of little value as an indicator of pollution except when compared with the normal for the region from which the sample was collected. By "normal chlorine" is meant the amount of chlorine present in the unpolluted water of any particular locality. Except in regions where there are natural deposits of salt, it is dependent chiefly upon its distance from the seacoast and upon the amount of exposure to ocean winds.

At the very outset of the work of Mt. Prospect laboratory it was thought wise to ascertain the normal chlorine for the watershed of the Brooklyn water supply. As pollution had already encroached to a considerable extent upon its western portion, it was decided to extend the observations to the entire island. There were two reasons why this seemed desirable—first, it was believed that the isochlors would be found to be approximately parallel to the shore line, and that the more exact location of the isochlors to be obtained in the sparsely settled regions would be of assistance in extending the lines over the watershed of the Brooklyn supply; second, in case event of an eastward extension of the supply the isochlors would be of value in estimating future pollution.

Accordingly, in October, 1897, a collector was sent over the island to secure samples from ponds, streams and wells that showed no evidence of pollution. Bottles were sent to him at various stations on the Long Island Railroad, and from these places as centers local trips were made by carriage and by bicycle. The general plan of collection was to obtain several series of samples in north and south lines across the island and a few scattered samples at the eastern extremity. In April, 1898, the collector made a second trip over the island and secured duplicate samples from some of the localities first visited, besides samples from some new regions. In these trips samples were collectted from 77 sources, and a few more were subsequently added. Many of these, however, had to be discarded, as they were evidently not normal. In certain places the only samples that could be obtained were from wells, and some of these were so near to houses and barns that contamination was apparent. Moreover, there were some regions near the center of the island where, during the October trip, the collector was unable to find any water at all, because of the sandy nature of the soil.

The samples that were apparently normal in their chlorine contents were used in the preparation of the map of normal chlorine for the island, shown by Fig. 5.

This map shows that except at the eastern end of the island and except near the coast the normal chlorine is below 6 parts per 1,000,000. On the south shore this isochlor is only two or three miles inland, while on the north shore it is probably three or four miles inland. The isochlor of 5 parts per 1,000,000 is about two miles further inland, and is substantially parallel with the former. The isochlor of 4 parts per 1,000,000 surrounds a narrow strip in the center of the island from 3 to 5 miles wide. In this region it is probable that the normal chlorine is even lower than 4 parts. The normal chlorine at the line of the aqueduct of the Brooklyn water supply, which is almost parallel with the southern shore, is about 6 parts per 1,000,000, but most of the streams that supply the ponds extend northward into the region where the normal chlorine is below 4 parts. It seems probable that the normal for the supply ponds is between 5 and 6 parts, and it may be assumed that any chlorine in these ponds in excess of 6 parts per 1,000,000 may be considered as due to the population dwelling upon the watershed.

In conclusion, the author wishes to express his thanks

FIG. 5.—NORMAL CHLORINE MAP OF LONG ISLAND.

to Mr. Robert Van Buren, Engineer-in-Charge, Department of Water Supply, Brooklyn, for permission to quote from unpublished laboratory records, and to acknowledge his obligations to Mr. I. M. De Varona, M. Am. Soc. C. E., Engineer of Water Supply, under whose general direction the laboratory was established and the system of work inaugurated, and to whom belongs the credit for its existence and success. The photographs of the laboratory that accompany this article were taken and kindly furnished by Mr. P. Schuyler Miller, the assistant chemist in the laboratory.

*The following account is abstracted from a paper written by the author in collaboration with Mr. D. D. Jackson and read before the New York Section of the American Chemical Society on March 9, 1900.